§59. Numerical Calculation for Neutral Beam Deposition on Impurity Mixed Plasmas

Ikeda, K.

In the last issue, I had reported the enhancement of beam deposition in a high temperature carbon pellet discharge. Strong beam attenuation was observed by the beam emission spectroscopy, and it calculated numerically by a beam stopping coefficient used ADAS analysis [1]. We mainly use hydrogen discharge in LHD experiments, and also additionally use a little Ar gas for a X-ray spectroscopy, Ne gas for a charge exchange spectroscopy and He gas for ICRF heating. To investigate a neutral beam deposition in a hydrogen plasma with mixture some impurities, I have calculated the beam deposition rate numerically using the beam stopping coefficient in the ADAS database [2].

In the numerical calculation for beam deposition, the typical density profile (n_e) and temperature profiles (T_e and T_i) are used as shown in Fig. 1. Along the beam injection axis L, the electron density increases to $n_e = 2.0 \times 10^{19}\ \mathrm{m}^{-3}$ as shown the chain line in Fig. 2. The local beam density $N_b(L)$ is given by the exponential decay function as follows ;

$$N_b(L) = N_b(P)exp(-\int_P^L n_e(l)S_{cr}(l)\sqrt{\frac{m}{2E}}dl), \qquad (1)$$

where $N_b(P)$ is the neutral beam density path through the beam injection port at the position of P, $n_e(l)$ is the local electron density, $S_{cr}(l)$ is the local stopping coefficient, m is the mass of the beam particles, and E is the beam energy. Figure 2 shows the beam attenuation profiles along the beam injection axis in the case of pure H, He and Ar target plasma. The beam attenuation rate of H, He and Ar target is 0.36, 0.21 and 0.02, respectively, at the beam amor tile.

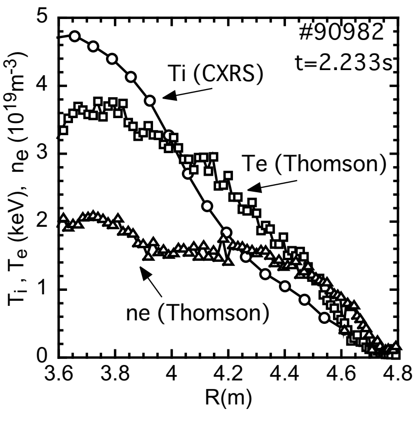

Fig. 1: Radial test profile of n_e, T_e and T_i in the discharge of LHD-90982 for numerical calculation of beam attenuation.

Figure 3 shows the beam deposition rate for hydrogen discharge with mixture argon, neon, carbon, helium or deuterium. Horizontal axis is the impurity fraction η defined as $\eta = N_{Im}/(N_{Im} + N_H)$, here N_{Im} and N_H is the impurity density and the hydrogen density in a target plasma, respectively. The beam deposition substantially increases to 84% with mixture of little argon at $\eta = 0.02$. Influence of carbon and neon is almost same, and the beam deposition increases to 87% at $\eta = 0.1$. In the case of helium mixture, beam deposition slightly increases to 67% at $\eta = 0.1$. The beam deposition for deuterium target is the same as the beam deposition for hydrogen target as shown circle marks in Fig. 3.

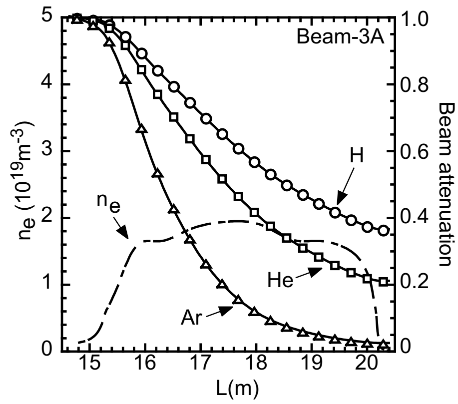

Fig. 2: Chain line is the distribution of n_e along the beam injection axis. Beam attenuation profile for pure H, He and Ar plasma are shown in circle, square and triangle marks, respectively.

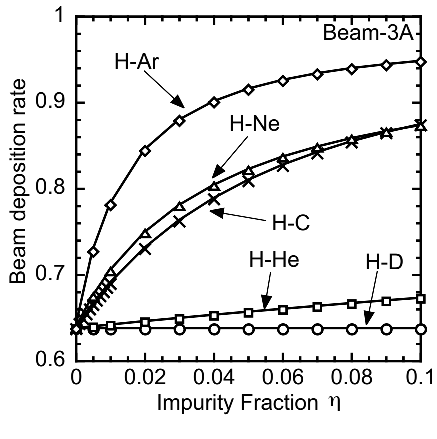

Fig. 3: Beam deposition rates for hydrogen plasma with impurities (Ar, Ne, C, He, D) calculated by the beam stopping coefficients from the ADAS database. Impurity fraction η is set from 0 to 0.1.

1) K. Ikeda, M. Osakabe, A. Whiteford, et al., Proc. of the 7th General Scientific Assembly of the Asia Plasma and Fusion Association (2009) P27p1-05.

2) H. P. Summers, et al., Research Report NIFS-DATA Series No. 55, Nagoya, November (1999).