# §6. Effect of Halo Neutrals from Bulk Ions on Fast-ion Charge Exchange Spectroscopy in LHD

Kobayashi, S., Yamamoto, S., Mizuuchi, T. (IAE, Kyoto Univ.), Lee, H.Y., Nagae, Y., Harada, T. (GSES, Kyoto Univ.), Murakami, S. (Dep. Nucl. Eng., Kyoto Univ.), Nakashima, Y. (Tsukuba Univ.), Osakabe, M., Kobayashi, M., Shoji, M., Ida, K., Yoshinuma, M.

The importance in halo neutrals in plasmas has been pointed out not only in the estimation of the absorption power and momentum profiles by the neutral beam injection (NBI) but also the fast ion charge exchange spectroscopy (FICXS). The velocity and the spatial distributions of the fast ions have been estimated by FICXS to estimate the confinement property of the fast ions and to understand the physics of the fast-ion-driven MHD activities. Since the halo neutral $H_{halo}$ is produced by the charge exchange reaction between the neutral beam atom $H_{NB}$ and bulk ion $H_{bulk}^+$ (i.e. $H_{bulk}^+ + H_{NB} \rightarrow H_{halo} + H_{NB}^+$), $H_{halo}$ is expected to be asymmetric according to the geometry of NBI. The emission from $H_{halo}$ by the collisional excitation with fast ion $H_f^+$ (i.e. $H_f^+ + H_{halo} \rightarrow H_f(n > 1) + H_{halo}^+$) affects FICXS since this component cannot be subtracted using background sightlines. In this study, we investigate the spatial profile of the halo neutrals aiming at estimating the effect of halo neutrals on FICXS[1]. The candidate for suitable viewing chord for FICXS for a helical device is discussed.

The spatial distribution of the halo neutral is calculated using a Monte-Carlo simulation code for the neutral particle transport. In this calculation, we introduce following assumptions to simulate the halo neutrals: (1) birthpoints of the halo neutrals are the same as those of the beam ions. (2) The initial velocity and its direction of the halo neutral are determined from the bulk ion temperature with Maxwell distribution. (3) The recycling coefficient at the wall is unity.

The test calculation is carried out using the plasma mesh model and the beam birthpoints for Heliotron J ($R/a$=1.2m/0.16m). The neutral beam injection and plasma geometry is shown in Fig. 1. A full-torus mesh model is used for the calculation which consists of 512, 28 and 15 sections in the toroidal, poloidal and radial directions, respectively. The halo neutral is localized in the beam path region. The radial profile of the halo neutral density differs from the birthpoint distribution. The neutral density at the plasma edge is 10 times higher than that at the magnetic axis. Since the halo neutral with the velocity corresponding to the ion temperature (0.3keV at the core) has a mean free path of around several tens cm, it can escape from the plasma and contacts with the wall surface. Moreover, since the reflection coefficient of the halo neutral is about 0.45, the recycled hydrogen molecule may dominate the neutral density transport in the radial direction. Therefore, the species, energy and recycling coefficient of the reflected neutrals are important to evaluate the precise transport of the halo neutrals in Heliotron J.

Figure 2 shows the radial profile of the halo neutral and the beam densities ($n_{Halo}$, $n_{beam}$) and ratio of them along with three candidates for FICXS viewing chords (A-C). In the case A, $n_{beam}$ is about twice of $n_{Halo}$ in the range of $-0.6 < r/a < 0.8$, but $n_{beam}$ is relatively low as compared with other cases. As for case B, relatively high $n_{beam}$ and significant density ratio are obtained simultaneously in range of $-0.6 < r/a < 1$. For case C, on the contrary, $n_{beam}$ is significant high only in the edge region. Therefore, case B or A are candidates for FICXS sightlines for Heliotron J.

1) S. Kobayashi, M. Osakabe, et al., Joint Conf OS2012 and PMIF2012, 2012.8.27-8.31 Tsukuba, Ibaraki, Japan, O-18.

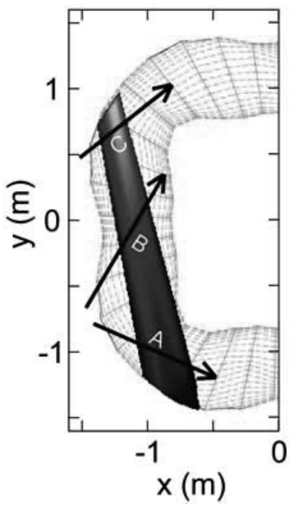


Fig. 1. Plasma and beam geometries for halo neutral transport calculation. Three candidates for FICXS viewing chord are denoted as A, B and C.

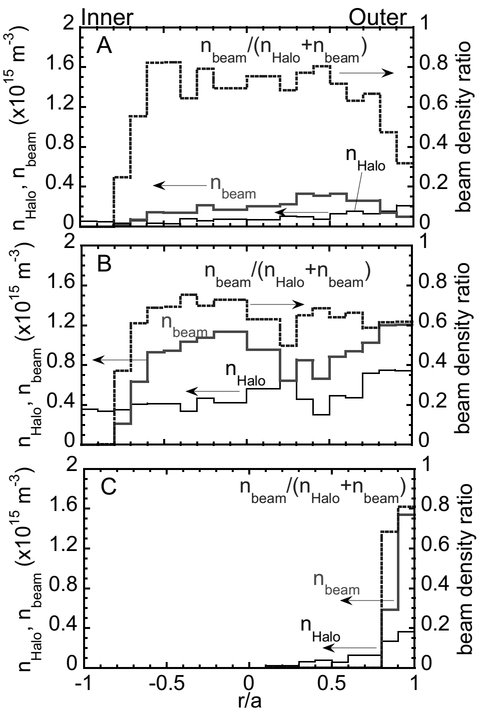


Fig. 2. Radial profile of $n_{Halo}$, $n_{beam}$ and ratio of them for three candidates of sightlines A-C.