Application of FIDA as a charge exchange loss measurement for NB-produced fast ions in small or medium-size devices

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In NBI heating experiments in small or medium-size toroidal devices such as Heliotron-J and CFQS, the charge exchange loss of NB-produced fast ions is not negligible in the determination of the fast ions' slowing down velocity distribution function. Although it may be possible for many numerical simulation methods for the fast ions to include this loss mechanism, experimental measurements of the neutral particle density profile in the 3-dimmensional real space as the input to such calculations are almost impossible. On the other hand, the FIDA (Fast Ion D-alpha) measurement[1] are widely used in various devices for investigating the local fast ion velocity distribution. In situations where the charge exchange loss is not negligible and the neutral particle density profile is unknown, this method is not useful for the purpose of the experimental validation of theoretical calculations of the velocity distribution. For the studies of beam-driven phenomena such as that in Refs.2-3, and the anisotropic pressure MHD equilibrium mentioned in Ref.4, however, the requirement on the velocity distribution is not in the detailed understanding on the slowing down process including the charge exchange loss but in the reduction factor of the lower Legendre order structures of the velocity distribution. In both the direct solving using the eigenfunction[3] and the indirect solving based on the adjoint equation method[4], it can be shown that for this purpose that the effect of the charge exchange loss on the velocity distribution will not appear in the pitch-angle space structure but will appear only in the energy space structure. When we find the substantial neutral particle density by comparison of the FIDASIM[1] calculation including this energy space reduction factor and the experimentally observed Balmer-alpha spectrum, we should include this reduction factor also in calculations of the beam-driven effects. [2-4] The measurement example in the Heliotron-J will be presented.

References

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