§18. Estimation of NBI Beam Pressure Including Orbit Effect

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In the high power heating by NBI or ICRF, the pressure due to fast ions becomes large. And then the plasma becomes high anisotropic pressure. The beam pressure and/or the pressure anisotropy significantly affect the properties of MHD equilibrium and stability[1]. In the LHD, a volume averaged beta has been reached 5% with the use of the NBs in the low field(B~0.5 T)[2]. It is pointed out that about 30% of the total pressure corresponds to the fast ion beam pressure. Therefore, it is one of the important issues to identify the beam-pressure in the total plasma pressure.

The beam-pressure can be numerically evaluated from the velocity distribution function of the fast ion produced by neutral beam (NB). The Monte-Carlo code based on the real coordinates (MORH)[3], which use the equilibrium magnetic field calculated by the HINT code[4], has been developed in order to calculate the velocity distribution function. The MORH code has an advantage that "re-entering fast ion[3]" , which re-enter in the region of the closed flux surfaces after they have once passed out of the Last Closed Flux Surface, can be taken into account.

We evaluated the beam-pressure produced by NBs in the typical LHD high beta discharge. For a comparison with measured beta values, the beta value of the beam component defined as

$$\beta_{beam}=2\mu_0 * (P_{beam\_||} + 2 * P_{beam\_\perp})/(3B^2) \qquad (1)$$

is used.

Figure 1 shows the beta value of the beam component evaluated by the MORH. In Fig. 1, the beta value of the beam component with the orbit effect is much smaller than that without the orbit effect. Including the orbit effect, the peak of the beta value shifts to the torus outboard because the input power of co-NB is the largest in the LHD high beta plasma and the orbits of fast ions by co-NB have a large effect.

The beta value of the beam component is compared with a dia-mag beta value (β_{dia}) and a thermal beta value (β_{th}) which is evaluated by the electron density and temperature (Fig. 2). In Fig. 2, the peak of beta value of beam component is almost same as that of the thermal beta in the LHD high beta plasma. On the other hand, the volume averaged beta valuse :$<\beta_{dia}>$~4.5, $<\beta_{th}>$~3, $<\beta_{beam}>$~1.5.

Finally, the effect of the re-entering fast ion on the beta value of the beam component is investigated(Fig.3). In the Fig.3 the re-entering fast ions have an effect in the rho~0.5 of the torus inboard and rho~1 (near the LCFS) of outboard. There is almost no effect of the re-entering fast ions in the peak value of the beta value of beam component.

In the future, we will model the profile of the beam-pressure for the equilibrium calculation including the anisotropic pressure.

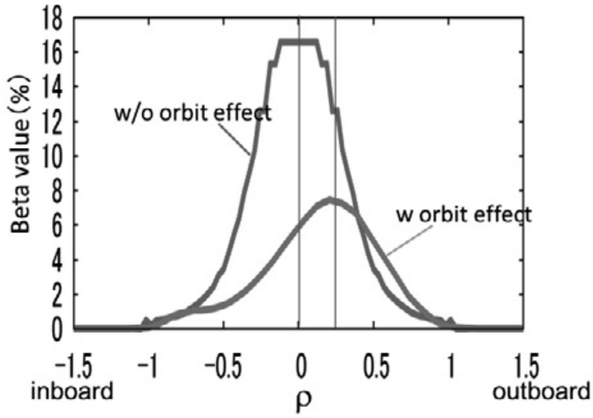

Fig. 1 The difference of the beta value of the beam component between with and without orbit effect on equatorial plane (Z=0) on the horizontally elongated poloidal plane.

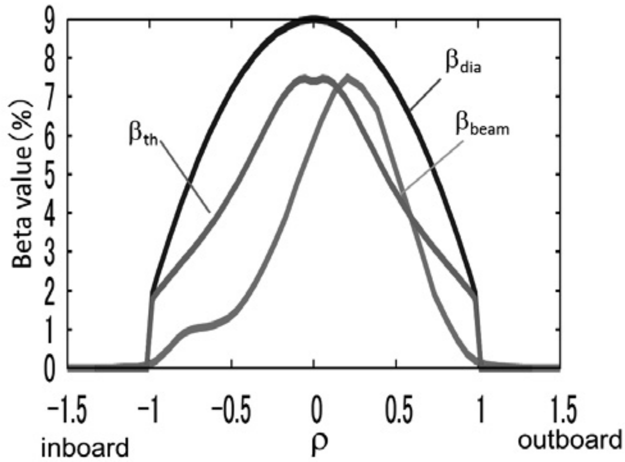

Fig. 2 Comparison between the beta value of the beam component and measured beta values.

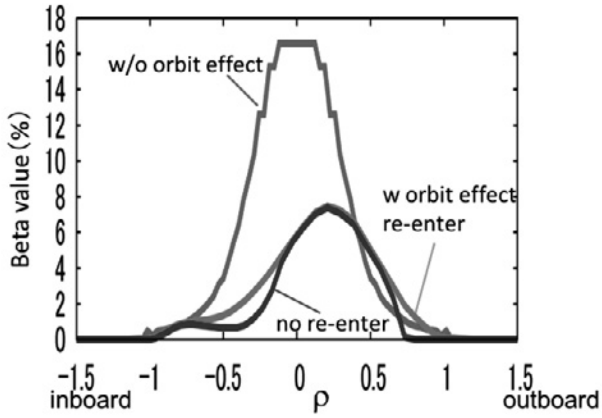

Fig.3 Effect of re-entering fast ion on the beta value of the beam component.

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