§25. ICRF Heating Experiment in Heliotron J

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ICRF heating experiment is performed with the special emphasis on the effect of one of the field Fourier component, bumpiness. The control of the bumpiness is a key issue for the design principle of the magnetic filed of Heliotron J, where the particle confinement is controlled by the bumpiness. The minority heating scheme is adopted in order to generate fast ions and heat bulk particles with a proton minority and a deuteron majority in Heliotron J, a low-shear helical-axis heliotron (R_0 = 1.2 m, a = 0.1-0.2 m, $B_0 \leq$ 1.5 T). The ICRF loop antennas are installed on the low-field side of the corner section of the Helitoron J.

The effect of the bumpiness on the fast ion energy spectra has already reported in the previous report. The amplitude modulation of the ICRF power is performed for estimating the confinement of the fast ions for the three bumpy cases; they are 0.01, 0.06 and 0.15 in ε_b. The injection power is modulated with the frequency of 100 Hz, and then the CX flux is modulated as well. The phase delay of the CX flux to the injection power is caused through the acceleration by RF wave, orbit loss and collision damping. The experimental results are shown in Fig. 1 for the two bumpy cases. For the low bumpiness, the phase delay cannot be determined since the flux is too small. The lines in Fig.1 indicate the results of the calculation using Fokker-Plank equations with the loss term. The loss time in the loss term is given as an input parameter shown in the figure. From this experiment, the confinement of the fast ions for the high bumpy ripple is longer than that for the medium. It is considered that the bumpy control is effective for the fast ion confinement in Heliotron J. A Monte Carlo calculation is also performed for the fast ion confinement analysis in Heliotron J configuration. An example of the loss region in the velocity space for medium bumpy case is indicated in Fig.2. Ions with v_{para} and v_{perp} are calculated without collision for 1ms. The confined ions are indicated by dots. Loss region corresponds to the blank area, which is prevailed on both side of v_{para} = 0. There is difference of the loss region among three bumpy cases. However, there is little difference in the calculated energy spectra with collisions among three cases.

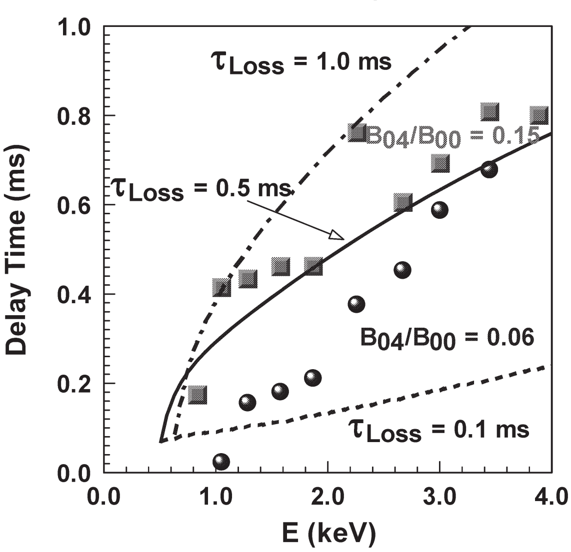

Fig. 1. Delay time of the high energy flux to the input power for two configurations.

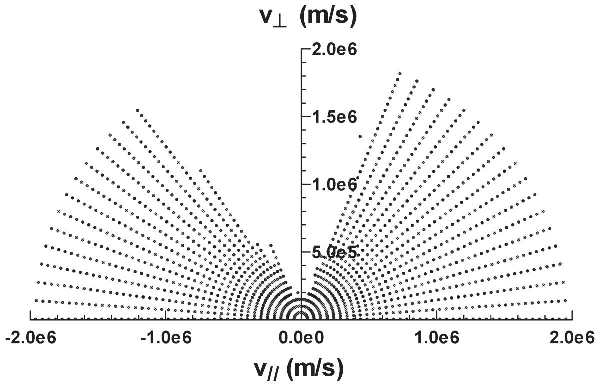

Fig. 2. Velocity loss region of the ions which start at (ρ, θ, ϕ) = (0.3, 0.0, 0.0) in the antenna cross section.

The ion temperature increases with P_{ICRF}/n_el under the center heating condition for three cases. Here, P_{ICRF} is the injected ICRF power and n_el is the line integrated density. The increment of the ion temperature in the high bumpy case is largest among three cases. Therefore, the heating efficiency is better in the high bumpy case. The bulk ion heating in this heating scheme is caused through the Coulomb collisions with the high energy minority ions produced by the ICRF heating. It is considered that the energy transfer from the minority ions is larger in the high bumpy case since the high energy tail is larger. The global energy confinement time in target ECH plasmas is almost same for three configurations except the improved confinement mode.

References

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