§13. Dependences of O-X-B Heating Effect on Experimental Conditions in CHS

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Evident increases in the plasma stored energy by applying 54.5 GHz electron cyclotron (EC) waves have been observed in overdense plasmas sustained by neutral beam injection (NBI) in the Compact Helical System (CHS). The heating effect was seen even for high-density of 8 x 10^{19} m^{-3}, that is, more than twice the cut-off density 3.8 x 10^{19} m^{-3} of the 54.5 GHz waves. The 54.5 GHz EC-wave beams were obliquely injected to high-density plasmas. Dependences of the heating effect on the experimental conditions such as the polarization and the injection power of the EC-waves, and the magnetic field were investigated.

The dependence of the O-X-B heating effect on the wave polarization was concisely confirmed by varying the polarization in 4 states: left-hand and right-hand circulars, and two orthogonal directions of linear. Here, the rotation angles of the polarizers for the two linear polarizations were those for X- and O-modes in the case of normal injection (perpendicular to the flux surface). The time evolutions of W_p with the 4 polarization states are plotted in Fig. 1. Among the 4 variations in polarization with the optimized beam direction, the left-hand circular polarization which was supposed to contain a high fraction of O-mode in the case of oblique injection revealed the best performance. The plasma stored energy W_p increased and the plasma was fully sustained till the end of the power injection. With other polarizations, though W_p increased once at the beginning of the power injections, the plasmas started to collapse during the power injections and vanished out fastest in the case of the right-hand circular polarization. Further optimization by using elliptically polarized waves to obtain pure O-mode wave for oblique injection would be possible, and it is left as a future work.

Dependence of O-X-B heating effect on the EC-wave injection power is seen in Fig. 2. The increment of W_p by the EC-wave injection is plotted as a function of the injection power. It is clearly seen that the increment of W_p linearly increases with the EC-wave injection power. This result with the electron density higher than the O-mode cut-off strongly affirms that the major cause of the increase of W_p is the B-wave heating via mode conversion from injected EC-waves.

Dependence of O-X-B heating effect on the magnetic field was investigated by magnetic field scan. As seen in Fig. 3, the increment of W_p increases with the magnetic field until B_{ax} = 1.9 T and it saturates or degrades over 1.9 T. Here, the increment of W_p is normalized with W_p just before the injection of the EC-wave power, considering the nearly linear dependence of W_p on B_{ax}. Fundamental resonance field for 54.5 GHz waves is 1.95 T. Both of the changes of the O-X-B mode conversion efficiency and the B-wave deposition position should be taken into account to explain the experimental result.

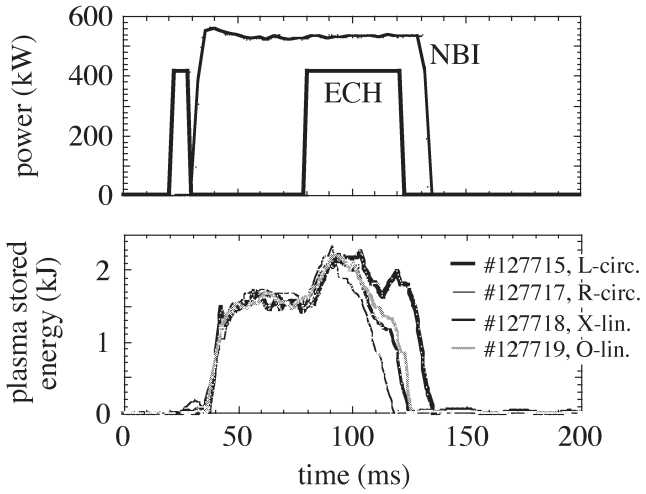

Fig. 1 Dependence on EC-wave polarization.

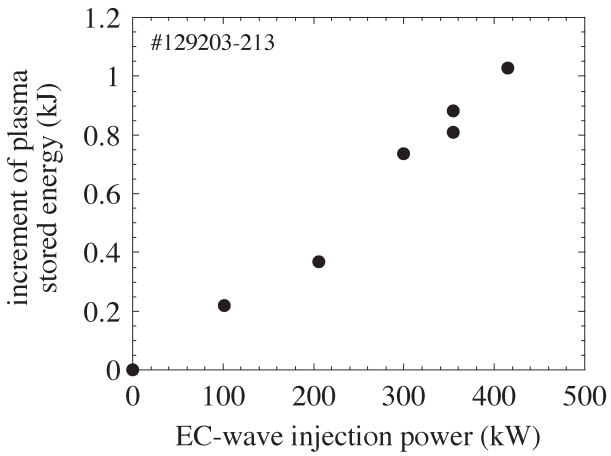

Fig. 2 Dependence on EC-wave injection power.

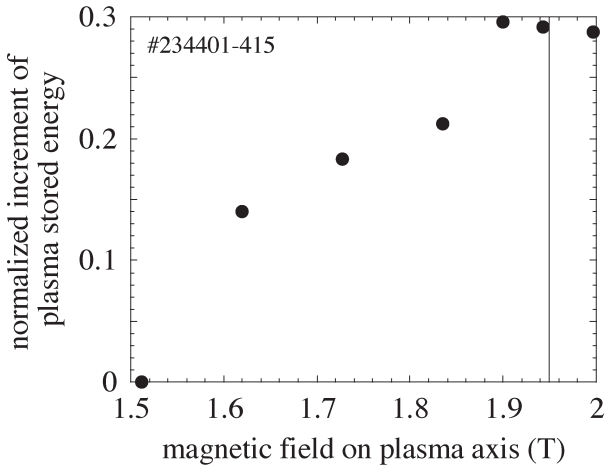

Fig. 3 Dependence on magnetic field.