§78. Density Clamping and Response to ECRH on Magnetic-ripple Top and Bottom

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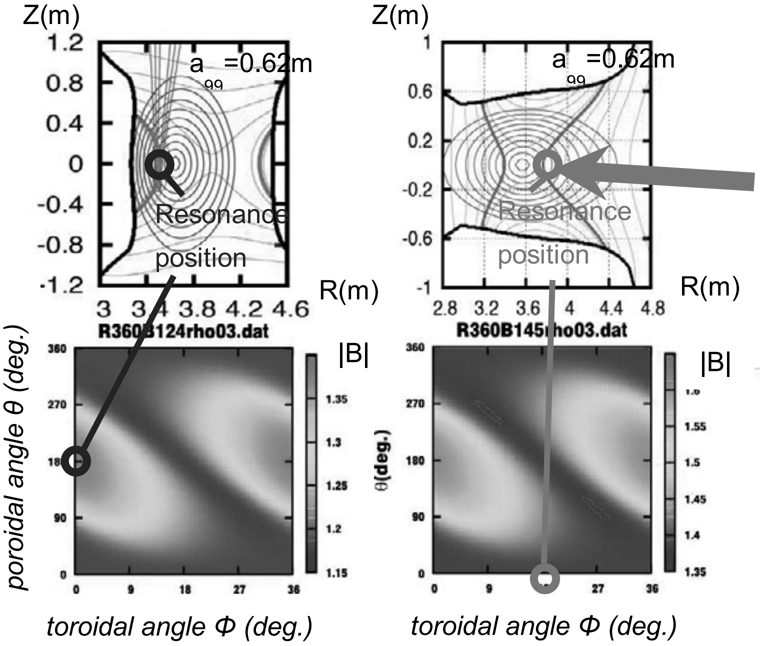
Density clamping or pump-out is observed in both tokamaks and helical systems during high power heating, particularly electron cyclotron resonance heating (ECRH). It also changes the electric potential to positive values. The change of the radial electric field structure has large effects on the confinement. The changes in the electron density and the radial electric field interact each other. Therefore, a good understanding of density clamping phenomena is important to achieve a good confinement and to clarify effects of the radial electric field structure on the confinement. Two possible mechanisms are discussed for the density clamping. One is the increase in the number of trapped particles, which can enhance radial particle flux, because ECRH accelerates electrons in the perpendicular direction to magnetic field lines. This is ECRH specific mechanism. The other is the confinement degradation due to instabilities like trapped electron modes. Such degradation of particle confinement is also observed in a tangential negative ion neutral beam heated plasma in LHD for low density discharges, where electron heating is dominant and heating in parallel to the magnetic field.

To distinguish these two effects, 1MW 77GHz ECRH has been superposed on NBI target plasmas at the magnetic-ripple top or bottom (Fig. 1), where the loss cone region is wider for the ripple bottom than for the ripple top, in the Large Helical Device (LHD). ECRH has been applied on the bottom of both toroidal ripple and helical ripple. Second harmonic X(X2)-mode ECRH has been used because X2-mode ECRH accelerates perpendicular speed more than fundamental O(O1)-mode. The power deposition profiles are set identical and sharp at the normalized minor radius $\rho=0.3$ for both cases. The magnetic field strength is adjusted to the second harmonic resonance condition (1.375T for 77GHz) at desired position. The electron density is about $0.6\times10^{19}\mathrm{m}^{-3}$ below the cutoff density of ECRH. The line integrated electron density is measured by multi-channel FIR laser interferometers. The local electron density is measured and estimated by both Thomson scattering and Abel transformed FIR interferometer. The electron temperature and electric potential are measured with Thomson scattering and a heavy ion beam probe (HIBP), respectively.

Fast and local decrease in the electron density and change in the electric potential have been observed for 5ms after the start of the bottom ECRH (Fig. 2). Both the electric potential and the electron density change rapidly only inside the heating position. Fast changes in the electric potential and the electron density don't occur outside the heating position. The change in the electric potential indicates that the ECRH induces non-ambipolar particle flux, and it is consistent with the electron density drop qualitatively.

Such fast changes are not observed in the top ECRH case. However, large differences in the electric potential and the electron temperature have been observed. The effective deposition power is estimated from the change in the slope of a stored energy. The effective deposited power has been 241kW and 546kW for the top and bottom ECRH cases, respectively. In order to estimate the flux enhanced by the production of trapped particles, further investigations are required.



(a) Top (b)Bottom

Fig. 1. Cross section of torus and Mod-B contour on toroidal poloidal plane on $\rho=0.3$. ECRH is applied on the magnetic ripple (a) top and (b) bottom.

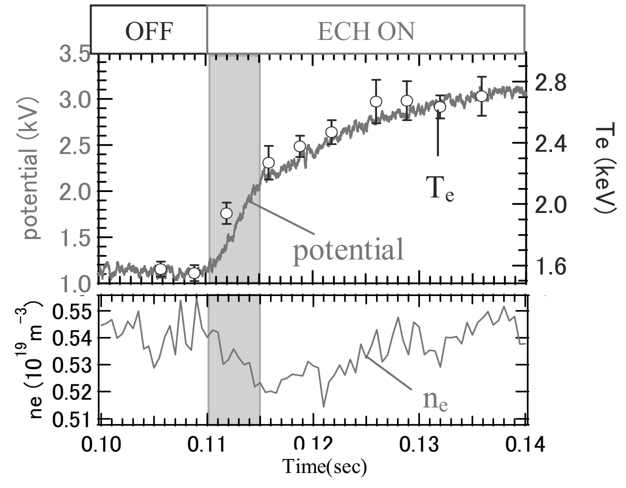


Fig. 2. Fast changes in the electron density and potential by ECRH on the magnetic ripple bottom.