§4. Behavior of Electron Temperature Profile with e-ITB during Long Pulse ECRH Discharge


The mechanism of an electron internal transport barrier (e-ITB)\(^1\) formation has been investigated in the LHD. In the 2009 experimental campaign, the spontaneous formation of the e-ITB was observed in the ECRH plasmas. The foot point of the e-ITB moved outward during the discharge and was close to reaching the rational surface of \(i/2\pi = 0.5\)\(^2\). However, the behavior of the electron temperature profile after the foot point of the e-ITB approached to the rational surface could not be clarified due to the limitation of the ECRH pulse duration. Thus the longer pulse discharge with enough heating power is necessary in order to investigate whether the e-ITB foot point stop the outward moving at the rational surface or not. From 2009 to 2010, it became possible to operate 77 GHz gyrotrons with higher electric efficiency due to the flexible control of the anode voltage. In addition to that, the gyrotrons with higher electric efficiency due to the flexible РФ81.png

Fig. 2. The time evolution of (a)-(d) \(T_e\) and \(\chi_e\) profiles (e) \(r_{\text{foot}}, r_{\text{in}}\) and \(r_{\text{out}}\), where \(\chi_e, r_{\text{foot}}, r_{\text{in}}\) and \(r_{\text{out}}\) are the electron thermal diffusivity, the radial position of the e-ITB foot point, the inner and the outer boundary position of the local flattening in the \(T_e\) profiles, respectively. The experiment was carried out under the configuration of \(R_{\text{ax}} = 3.53\ \text{m}/B_t = +2.705\ \text{T}\). The target plasma with the averaged electron density of \(0.3\times10^{19}\ \text{m}^{-3}\) was sustained for \(3\) seconds by two lines of perpendicularly injected ECRH (1.34 MW). At the beginning of the discharge, a flat \(T_e\) profile was observed and a peaked \(T_e\) profile was formed at \(t = 0.9\ \text{s}\). After that \(r_{\text{in}}\), which corresponds to the foot point of the e-ITB, moved outward. On the contrary, \(r_{\text{out}}\) shifted inward and the local flattening gradually shrunk. It was found that \(r_{\text{in}}\) reached slightly inside position of the rational surface of \(i/2\pi = 0.5\) and then the local flattening around the rational surface disappeared. After the healing of the local flattening, \(r_{\text{foot}}\) stopped outward moving, namely the foot point of the e-ITB did not move across the rational surface. In addition, the degradation of the \(T_e\) gradient was observed at the plasma core region in the latter phase of the discharge. The detailed verification of the role of the lower-order rational surface to determine the e-ITB structure and the study of the topology change in the magnetic structure during the e-ITB growing are the future works.


Fig. 1. The output energy of 77 GHz gyrotrons in the high power operation since 2007 experimental cycle

Fig. 2. The time evolution of (a)-(d) \(T_e\) and \(\chi_e\) profiles (e) \(r_{\text{foot}}, r_{\text{in}}\) and \(r_{\text{out}}\)