§46. Study of Heat Transport before and after Superimposed ECH

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Modulated power injection of the millimeter wave for electron cyclotron heating (MECH) is a powerful tool to investigate the characteristics of heat transport in the plasma. In LHD, the improvement name as "core electron root confinement (CERC)" has been obtained and studied by launching of the focused millimeter wave toward the core region. and investigation of heat transport in CERC plasmas with MECH has been performed. The experimental results obtained in the 11th experimental campaign suggest the existence of a kind of boundary. A significant power deposition inside the boundary causes the transition to CERC. Recently 77GHz high power (~1MW/several sec.) gyrotrons have been installed. The transition to CERC by launching of the focused millimeter wave from one transmission line has been expected in sufficiently high density plasma where the reliable measurement of thermal electron cyclotron emission (ECE) is possible. Therefore it is expected to investigate the dependence of the transition condition on the power deposition region for understanding the role of the boundary.

In the 12th experimental campaign, in a magnetic configuration (R_{ax}, B_{ax}) = (3.6m, 2.75T) the heat transport before and after superimposed ECH has been investigated for target plasmas sustained by 82.7GHz (191kW) and 77GHz (542kW) ECH or Co-NBI or Cntr- NBI. The superimposed ECH was performed by 77GHz (624kW) millimeter wave launching from one transmission line. 84GHz (279kW) millimeter wave was launched for MECH with 29Hz, 100% power modulation before and during the superimposed ECH. Fig.1 shows the electron temperature profiles, profiles of 29Hz perturbation phase and amplitude obtained by FFT analysis of ECE signals before and during the superimposed ECH. The millimeter wave was launched toward the ECR layer located at ρ~0.15 for superimposed ECH and toward the ECR layer located at ρ~0.7 or 0.8 for MECH. The aiming point for MECH was selected to avoid the boundary described above. The central electron density was set to be 0.4 x $10^{19}m^{-3}$. In the ECR plasma, after superimposed ECH the delay of the phase increases around the MECH region where the bottom of the phase appears. On the other hand, the delay of the phase slightly decreases from the infliction point of the electron temperature profile at R~3.15m. In the NBI-Co plasma, the delay of the phase around the MECH region does not change clearly. In the NBI-Cntr. plasma, the delay of the phase slightly decreases in the region R < 3.15m. Note that the profiles of the delay of the phase seem to become meaningless in the region R > 3.3m (ECR and NBI-Co.) and R > 3.2m (NBI Cntr.) after superimposed ECH. One possible reason is that the perturbation amplitudes of the ECE signals are very low there. Another reason is the effect of the non-thermal radiation of the high-energy electrons generated by the MECH in the peripheral region as the fact that the perturbation amplitude is high in the peripheral region far from the MECH region suggests. The density might be still low there. The aiming point for MECH could not set close to the magnetic axis with avoiding the boundary because the ECR layer of 84GHz does not cross the magnetic axis in this magnetic configuration. Higher density is required to estimate the heat transport correctly with use of ECE, however in the experiment when we increased the amount of gas puffing to increase the central electron density in the ECR plasma up to 0.5 x $10^{19}m^{-3}$, the density increased drastically up to 1 x $10^{19}m^{-3}$ and the steep electron temperature profile could not be obtained. The higher power injection and higher density are required to sustain the ECR plasma and to estimate the heat transport correctly with use of the ECE signals.

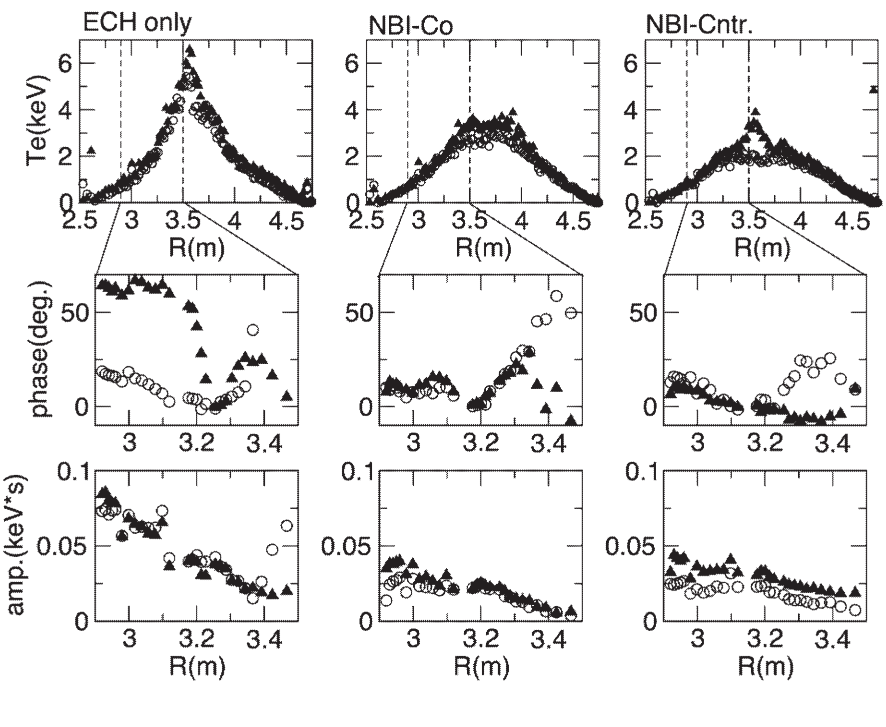

Fig. 1: Electron temperature profiles and profiles of 29Hz perturbation amplitude and phase obtained by FFT analysis of ECE signals before (circles) and during (triangles) superimposed millimeter wave launching aiming ρ~0.15. The target plasma was sustained by only ECH (left column), by NBI- Co (center column) and by NBI-Cntr. (right column) respectively.