§3. Investigation of the Heat Pulse Propagation in Plasmas of Various Temperature Profiles with MECH

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Modulated electron cyclotron resonance heating (MECH) is a powerful tool to investigate the heat propagation in magnetically confined plasmas. In LHD superimposed injection of the ECRH power above a threshold level to the central region of the plasma improves the thermal transport of the electron in the central region and causes the formation of the electron internal transport barrier (e-ITB). Heat transport were analyzed before and after superimposition of ECRH in plasmas sustained by Co or Cntr. NBI.[1)]

In the last 13th experimental campaign, heat transport in the ECR plasma newly investigated with MECH. Fig.1 shows discharge waveforms in the experiment. 77GHz millimeter wave was launched in the plasma at 4.15s after NBI was shorted. After 0.1s later of the turning on the first pulse, 100%, 98Hz power modulation started. At 4.66s, the second ECRH was superimposed from two transmission lines. The launched beam for MECH aimed ρ~0.10 at the midplane and another beams of the second superimposed ECRH of 77GHz aimed ρ~0.07 and 0.15 respectively. Signals of ECE were modulated coincident with MECH from the inner channel (R=3.56m) to the outer channel (R=2.92) since the start of MECH. In Fig. 2 time change of the electron temperature profile is shown. During the plasma was sustained by the first pulse of MECH, profiles of radiation temperature of ECE and Thomson scattering coincide with each other. After the second superimposed ECRH, they are different in the regions where R < 3.1m and R> 3.45m. The disagreement in the former region may be cause by emission of high energy electrons generated in the central region. Since the electron density decreased after the second superimposed ECRH the optical thickness might not be enough in the peripheral region. The disagreement of the latter region may cause the relativistic shift of the emission layer. In the right side of the same figure profiles of the perturbation amplitude of 98Hz and the phase delay from the MECH pulses are plotted. The peak of the perturbation amplitude is located in the central region of the plasma and the bottom of the phase delay is in the same region at t=4.6s. Therefore it is confirmed that the MECH power was absorbed in the central region. At t=4.6s when the only MECH was applied, the phase changed slowly between the long dashed line and dot long dashed line. The gradient of the temperature profile slightly changed at the dot-dashed line. Between the dot-long dashed line and dashed line, the phase changed fast. Between the dashed line and the dot dashed line, the phase changed inversely. There might a magnetic island structure in the region. In the region ρ > 3.05, the phase changed inversely too. As shown in the right column in Fig. 1, perturbation can be seen significantly in the channel that observe even ρ =2.921. This progress of the phase delay should be verified carefully for radiation region of the thermal electrons and the effect of super thermal electrons. At 5.1s when the second ECRH was superimposed, the gradient of the electron temperature profile changed slowly between the long dashed line and the dot long dashed line similar to the former case at t=4.6s. The phase did not change inversely between the dashed line and dot dashed line at this time, however the gradient of the phase delay seems to change at the dashed line, where the temperature gradient also changes.

In Cntr. NBI heated plasma and Co. NBI heated plasma heat propagation was also investigated with MECH. The position and shift of the barrier region should be compared to understand the formation process of e-ITB.

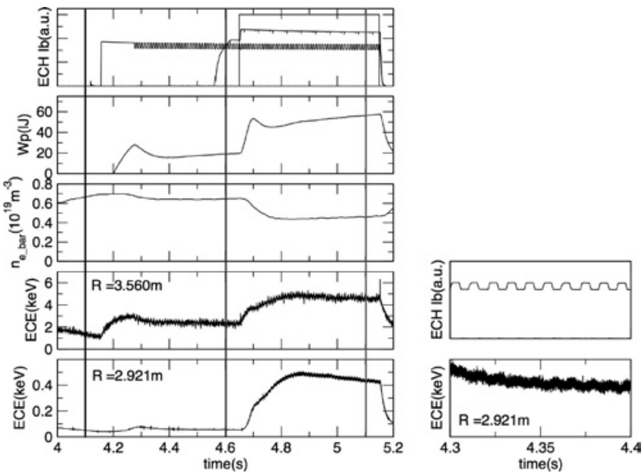

Fig. 1 :, Discharge waveforms of the ECR plasma.

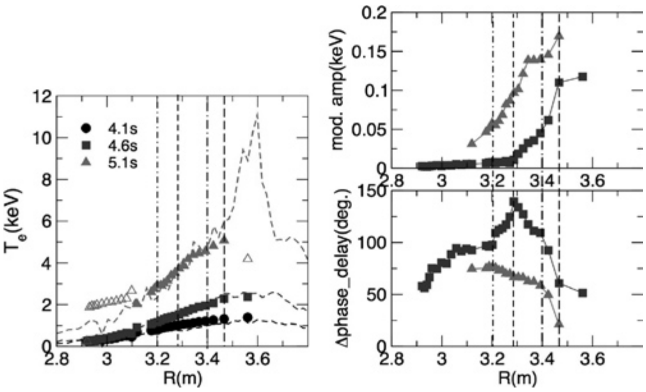

Fig.2: Time change of the electron temperature profile obtained by ECE (symbols) and Thomson scattering (dashed lines) in the ECR plasma. Profiles of 98Hz perturbation amplitude and phase delay from the MECH. They are obtained from the FFT analysis

1) Shimozuma, T. st al: Nuclear Fusion **45** (2005) 1396