§6. Measurement of the Transport Characteristic Using Modulation ECH in High Ion Temperature Plasma

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It is important issue to make realize the high temperature plasma in fusion oriented plasma devices including Large Helical Device (LHD), to demonstrate the ability of realizing reactor relevant plasmas. On LHD, the high ion temperature discharge is achieved after a carbon pellet injection into the plasma which is maintained by subsequent radial Neutral Beam Injection (NBI). At the high ion temperature discharge, the ion temperature radial profile often shows the flatting shape at the central region[1]. The flatting profile is considered to be a factor that suppresses the value of the ion temperature at center. The experiment using modulation electron cyclotron heating (ECH) is reported to investigate the mechanism of central flatting. Although the ion temperature profile and the electron temperature profile are not necessarily similar at the time of high ion electron discharge, the structure of magnetic field line, which could determine the temperature profile and transport, can be investigated using propagation of electron heat pulse.

Figure 1 shows the waveforms for a discharge of high ion temperature with modulation ECH. A carbon pellet injection at t=3.85s and additional NB-injection make ion temperature higher. At that time, the power modulated ECH is injected to make the heat pulse on electron temperature. The modulation frequency is 30 Hz. The decreasing at a carbon injection and propagation of the heat pulse are observed by electron cyclotron emission (ECE) as shown in Fig.2. The frequency resolution of ECE is 1 GHz. It corresponds to a spatial resolution of $\Delta r \sim 0.02$m. The phase delay and spectrum power of the perturbation with 30 Hz, are easily calculated.

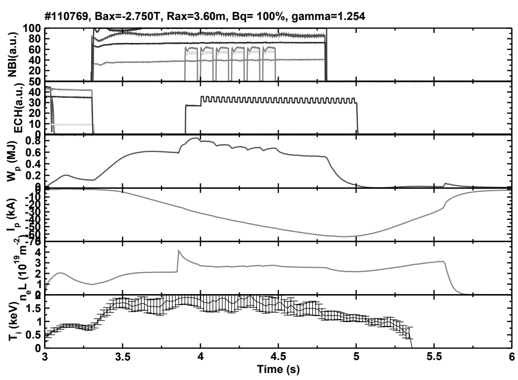

Fig. 1: Wave form for input power by NBI, input power by ECH, stored energy, toroidal current, line integral electron density, ion temperature in descending order

After carbon pellet injection t = 4.2, the ion temperature flatting at center region ($R < 3.9m$) is observed, while the shoulder of the electron temperature profile is at ($R < 4.05m$) as shown in fig.3 (a). We can see that the generated heat pulse around ($R \sim 4.1$m) propagate outward and inward. We have to note that the bottom peak of both spectrum power and phase. This fact indicates the existence of the magnetic islands whose center is the location of the phase bottom. There is a possibility that the ion temperature flatting is caused by generation of the magnetic islands. However There are still doubtful and unclear points such as the difference of the location between the shoulder point of ion temperature profile and the edge of the magnetic islands. Further investigation with care is necessary to determine the magnetic structure and mechanism of flatting.

1) Osakabe, M., *et. al.*, Annual Report of NIFS April 2010-March 2011, p14.

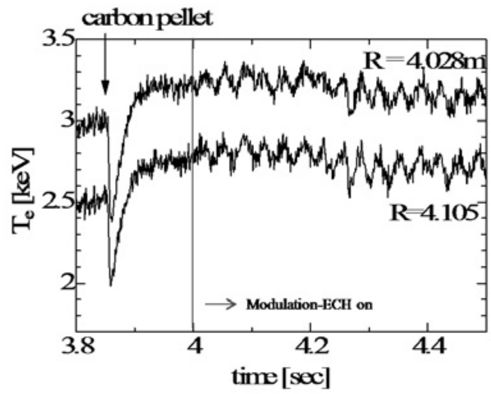

Fig. 2: The wave form electron temperature perturbed by modulation ECH.

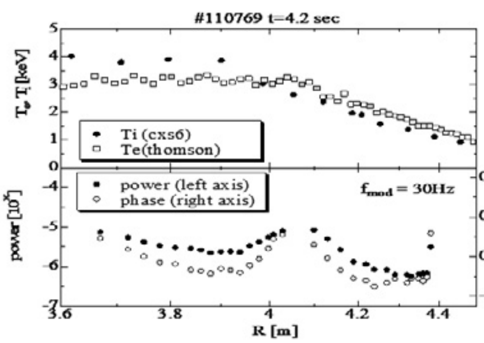

Fig. 3: (a) Ion temperature profile measured by CXS and electron temperature profile measured by thomson scattering, (b) characteristics of the propagation of perturbed electron temperature pulse.