§16. Temporal Evolution of Potential Measured with Heavy Ion Beam Probe on LHD

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From recent studies in many toroidal devices, it has been revealed that the strong shear of electric field can suppress the turbulence in plasma, which results in the improved confinement mode such as H-mode, ITB etc. In helical devices, non ambipolar radial electric field is produced, and the state where positive electric field is produced is called as “electron root”, and the state where negative electric field is produced as “ion root”. By producing the electron root in the central region and the ion root in the outer region of plasma, strong shear of electric field is made, which leads to the creation of ITB in helical devices. The measurement of radial electric field is very essential to study these improved confinement mode. In order to measure the potential in the plasma, we have been developing a Heavy Ion Beam Probe (HIBP) in LHD [1]. Up to now we succeeded to obtain the temporal evolution of signal from the HIBP system.

The accelerator of our HIBP system has a problem in the operation of accelerating voltage higher than 1.3 MV (beam energy of Au^+ for this case is 2.6 MeV because we use a tandem accelerator), which is the accelerating voltage for the operation on the toroidal magnetic field of 1.9 T. Therefore, we tried to measure potential at 1.5 T in LHD. Typical parameters of the LHD magnetic configuration in our experiment were as follows: major radius R_{ax} = 3.6 m, pitch parameter γ = 1.254, quadrupole filed B_q = 100 %. In this experiment, the plasma was produced and sustained by a counter injection NB heating. In Fig.1 (a), temporal evolution of line averaged density, and heating methods are shown. Two shots having different density are shown here. In Fig.1 (b), the time evolutions of potential measured with HIBP are shown. The observed point (sample volume) is at the plasma center. We were able to observe the secondary beam in no plasma case, because the secondary beam was made by neutral gas scattering. Zero level of potential was determined by it. Additional EC heatings are applied from 1 sec to 1.45 sec. In this duration the potential increases abruptly. The increase of potential in low density case (#70222) is larger than high density case (#70224). The typical time constant of this increase is 24 ms, which is relatively large compared with the time constant observed in bifurcation phenomena of other devices.

Temperature profiles of the shot #70222, at the time of 0.945 s (before ECH) and 1.3 s (during ECH), are shown in Fig.2. ITB can be seen at the center of plasma, and the increase of temperature from 0.945 s to 1.3 s at the center is about 3 keV, which is the same order of potential increase measured with HIBP (~2keV). The profile of potential could not be measured with a good accuracy, because the calibration of beam orbit was not sufficient in this experiment. In order to improve the control of beam incident angle, we will develop the new beam deflector.

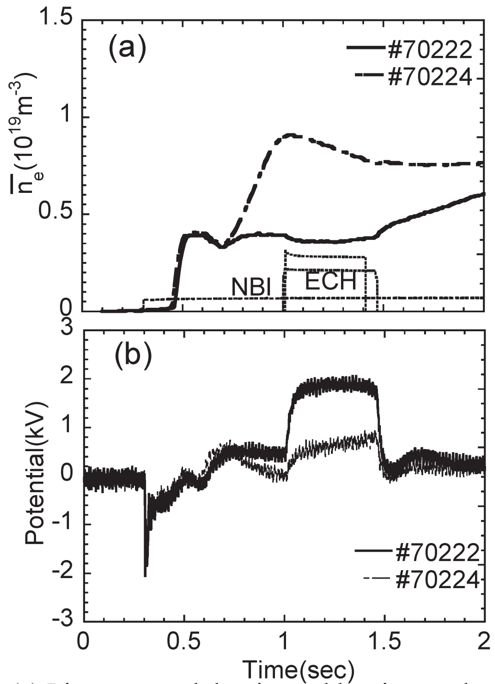

Fig.1. (a) Line averaged density and heating methods. (b) temporal evolutions of potential measured with our HIBP.

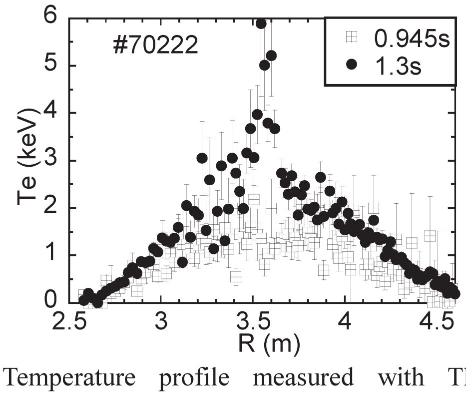

Fig.2. Temperature profile measured with Thomson scattering diagnostics at the time of 0.945 s and 1.3 s.

Reference
1) T. Ido, et al., Rev. Sci. Instrm. 77, (2006) 10F523