§13. The Bifurcation-like Behavior of Potential in LHD

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In magnetically confined devices, the radial electric field is a very important parameter because it makes an effect on its confinement property. In LHD, a heavy ion beam probe (HIBP) has been developed to study confinement physics related to the radial electric field. HIBP has a good temporal resolution (~a few hundred kHz in LHD) so it is used to measure fast change of plasma potential in the core region. In helical device, the radial electric field is considered to be determined by the ambipolar condition in the context of neoclassical theory. In some cases, multiple roots are obtained for the radial electric field (so called, electron root and ion root). In this case, if plasma parameters are changed temporally, one of these multiple roots disappears, and the abrupt jump in radial electric field (bifurcation phenomenon) will be observed. In LHD, the fast change of potential related to this bifurcation may be observed, so we show those experimental results.

The experiment was done on the following condition. The magnetic field strength was 1.5 T, the major radius of magnetic axis was 3.6 m, the pitch parameter was 1.254, the quadropole field component was 100 %. The acceleration energy of probe beam was 1.55 MeV for this configuration. The plasma was produced and sustained by balanced tangential neutral beam injection, NBI#1 (Counter) and NBI#2 (Co). In Fig.1 (a), the temporal evolution of line averaged density and heating methods are shown. NBI#1 and NBI#2 are injected at the time of 3.2 s and are turned off at 4.8 s. The vertical neutral beam (NBI#5) is injected from 4.7 s. The line averaged density increases at the moment of tangential neutral beam injection (3.35 s), but the density decreases after about 0.1 s of injection. And the line averaged density increases again after switching from NBI#1 and #2 to NBI#5 (4.7 s).

In Fig.1 (b), the temporal evolution of plasma potential at the center of plasma measured with HIBP is shown. The plasma potential increases from 3.4 s with decrease of line averaged density. And it decreases after the neutral beam switching of 4.8 s from tangential beam line to vertical. The magnification of potential and density time evolution in density decreasing phase (3.45~3.55 s) and increasing phase (4.80~4.90 s) is shown in Fig. 2(a) and 2(b) respectively. The abrupt potential increase and decrease are seen at 3.48 s and 4.858 s. This fast jump of potential is considered to be related to a bifurcation phenomena. In the electron temperature from ECE signal, the change at the same time is also observed. The comparison of these experimental results with neoclassical theory is a future issue.

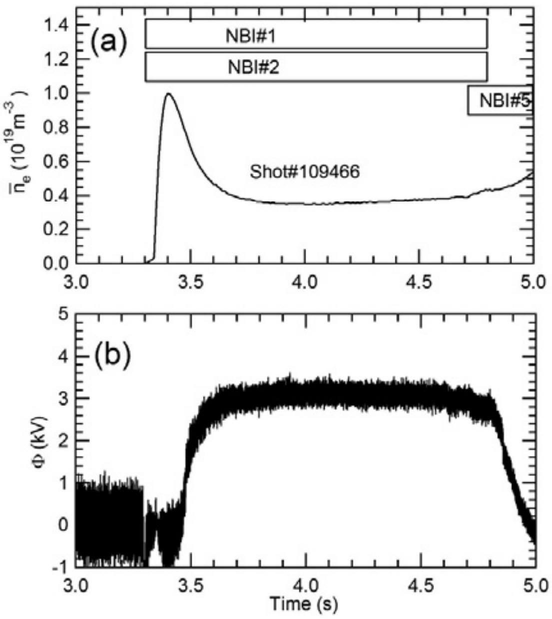

Fig. 1. (a) Temporal evolution of line averaged density and heating methods (b) Temporal evolution of potential at the plasma center measured with HIBP

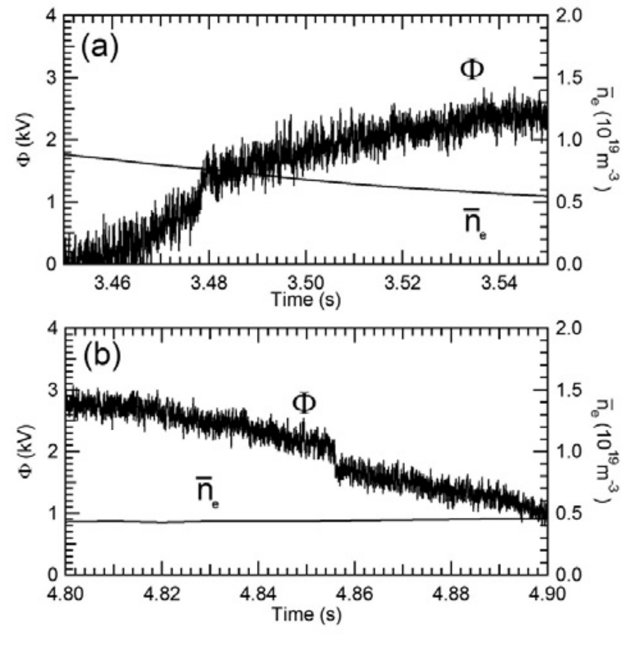

Fig. 2. (a) Temporal evolution of potential and line averaged density in the density decreasing phase (3.45~3.55 s) (b) Those in the density increasing phase (4.80~4.90 s)