§31. Plasma Response of Helical Plasma during Current Quench Phase

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The final goal of this study is to clarify physical mechanism to determine the current decay time in magnetically confined toroidal plasmas, because the precise prediction of current decay time during tokamak disruptions is one of the most critical issues in next generation tokamaks such as ITER.

The database of current quench decay times during disruptions has also been set up among the different tokamaks based on *L/R* model. The validity of the *L/R* model has not been confirmed yet. The difficulty may come from the co-existence of different mechanisms to determine current decay time τ during the current quench, such as atomic/molecular processes associated with electron cooling and rapid change of magnetic surface in tokamaks. On the other hand, in helical devices, we can distinguish the influences of atomic/molecular processes and the magnetic surface change on the current quench because the helical devices always keep magnetic surfaces externally. Therefore, the systematic study of the current quench in the helical system can give better understanding of the mechanism of the current quench in tokamaks.

In the previous campaign, we used unbalanced neutral beam injection (NBI) in order to generate plasma current. It is found that an effect of energetic ions generated by NBI influenced greatly in plasma current decay time. Therefore, we evaluated the *L/R* model in the discharges without NBI. In the discharge shown in Fig. 1(a), NBI (unit No. 2) is intercepted at $t = 4.3$ s and perpendicular NB's (unit No. 4a, 4b) are injected afterwards. Sudden drop of plasma current occurs at $t = 6$s just after the perpendicular NB's turn off. Plasma resistance and plasma inductance are evaluated from electron temperature profiles measured with Thompson scattering measurement.

Figure 1 (b) shows the time evolution of plasma resistance R_p and plasma inductance L_p calculated from T_e profiles. It is found that plasma resistance and inductance almost constant from $t = 5$s to 6s, and plasma resistance R_p increases dramatically in the time domain where the plasma current decreases after $t = 6$s.

In order to evaluate the *L/R* model, we compare between $\tau_{L/R}$ and τ_{exp}. τ_{exp} is the plasma current decay time obtained from the plasma current waveform, and $\tau_{L/R}$ is estimated from plasma resistance R_p and plasma inductance L_p in Fig. 1(b). In the time domain ($t > 6$s) when the plasma current rapidly decays, $\tau_{L/R}$ matches τ_{exp} very well. On the other hand, at $t = 5 \sim 6$s, $\tau_{L/R}$ is different from τ_{exp}, probably because energetic ions still survive in this time domain, or there is bootstrap plasma current. We need to evaluate plasma current induced by energetic ions and bootstrap current to clarify the validity of *L/R* model in this region.

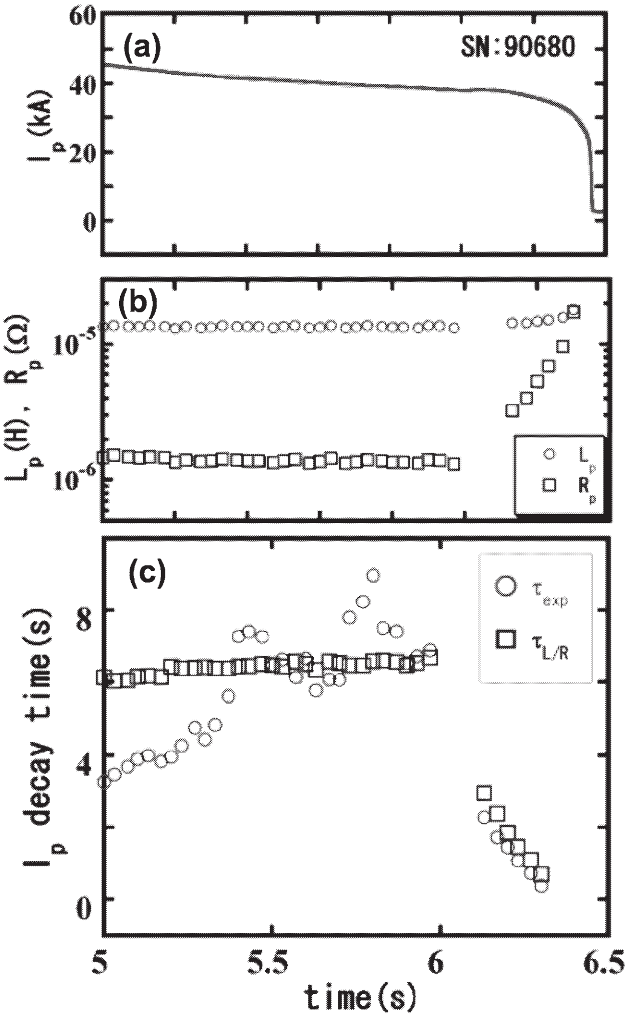

Fig. 1 Temporal evolution of (a) plasma current I_p, (b) plasma resistance R_p and plasma inductance L_p calculated from T_e profiles, (c) plasma current decay time $\tau_{L/R}$ calculated by L/R model. τ_{exp} is the plasma current decay time observed in the experimental plasma current waveform.