Study of plasma current in tokamak and helical devices

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In tokamak devices such as ITER, the plasma is confined by the magnetic field generated due to the plasma current as well as the external magnetic field coils. Therefore, understanding of quench of the plasma current, such as disruption, has been one of the most critical issues in the tokamaks. On the other hand, the helical devices do not require plasma current in order to confine the plasma because the helical devices always keeps magnetic surfaces externally. However, the unexpected plasma current generated by such as unbalanced Neutral Beam (NB) injection and bootstrap current have an influence on the plasma operation. Therefore, the control of the plasma current is also important in helical devices.

The final goal of this study is to clarify physical mechanism to determine the current decay time in magnetically confined toroidal plasmas. In this presentation, we focus on the plasma current decay at the end of the normal plasma discharges both in tokamak and helical devices.

In the end of typical JT-60U discharges without the disruption, the positive spike of the plasma current associated with the rapid current decay was observed when the plasma current decreases to about 20% of the flat top of the plasma current. The positive spike of plasma current was usually observed just before the rapid current decay. It was considered that the positive spike occurs in the relation with the rapid change of the plasma current density profile, which was observed from measurement by using the magnetic sensors [1]. However, in the plasma current generated by unbalanced NB injection in the LHD, no positive spike of the plasma current was observed, although there was the rapid decay of the plasma current observed. The understanding of the determine mechanism of the decay time of the plasma current is rather than poor at this moment.

Comparison of the plasma current decay between tokamak and helical devices mentioned above suggests that there are different mechanisms to determine the rapid plasma current decay. In order to reveal the determining mechanism for current decay time, we carried out the detailed observation of the plasma behavior at the current quench phase in the LHD by using Thomson scattering system as well as the visible spectroscopy measurement. At the beginning of the fast decay phase of the LHD, it was found that the He I intensity increased dramatically even at low Te, which indicates that the volume plasma recombination occurs.

[1] I.H. Hutchinson, Phys. Rev. Lett.p, **37**, 338 (1976).