§30. Minor Collapse of Current-Carrying Plasma in LHD

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A minor collapse observed in current-carrying plasma has been investigated in Large Helical Device (LHD). Experiments were carried out in the configuration with a high central rotational transform of $\iota_0/2\pi = 0.58$ in order to decrease the magnetic shear around the $\iota/2\pi = 1$ surface. The target plasma is produced and maintained by the neutral beam injection (NBI), which drives the plasma current I_p in the co-direction. When the beam-driven current exceeds a certain value, the $m/n = 1/1$ mode (here, the m and n are the poloidal and toroidal mode number, respectively) grows and causes a sudden drop of the plasma stored energy w_p (collapse) and the electron temperature T_e, and it also limits the plasma current itself. Before the collapse, the time evolution of the w_p and T_e are almost constant, while the I_p continues rising and the finite perturbed magnetic field with $m/n = 1/1$ mode b_{r11}/B_t, which is the radial magnetic component of the $m/n = 1/1$ mode estimated by the magnetic flux measurement, gradually increases. When the I_p/B_t (here, B_t is the toroidal magnetic field) reaches 39 kA/T, the electron temperature T_e measured with an electron cyclotron emission (ECE) diagnostic suddenly drops while the b_{r11}/B_t, increases. At that time, the decay time of the w_p becomes ~40 ms and the growth time of the b_{r11}/B_t is about 30 ms, which are slower than the growth time (~ 100 μs) of the ideal MHD phenomenon. The magnetic fluctuation and the soft X-ray diagnostics do not show any precursors or post-cursors of the collapse. After the collapse, the b_{r11}/B_t increases faster than before the collapse and the width of the flat region of the T_e profile expands toward the plasma center region. As a result, the central electron temperature decreases from $T_{e(0)} = 1.2$ to 0.6 keV. The increase of the width of the flat region of the T_e profile indicates the growth of the magnetic island with $m/n = 1/1$ structure by the development of the perturbed magnetic field. The toroidal angle of the X-point of the mode at the outboard side maintains a certain value during the discharge, which means that the mode almost does not rotate. The position of the flat region corresponds to the $\iota/2\pi = 1$ resonant surface, which is measured with motional Stark effect spectroscopy (MSE) diagnostics in which the current density profile is parabolic. The plasma discharge is not terminated by this collapse. A collapse was observed in the current-carrying plasma in Heliotron-E [1], and the collapse was explained by the appearance of the $m/n = 1/1$ internal kink mode at the $\iota/2\pi = 1$ resonant surface in the negative shear ($d\iota/d\rho < 0$) region of the rotational transform profile with the double resonant surfaces. In this experiment, the $\iota/2\pi$ profile is not a double resonant one. Therefore, it seems that a physical mechanism different from that described in Ref.[1] exists in this experiment.

Reference

1) Wakatani M. et al., Nucl. Fusion **23**, (1983) 1669