§47. Growing Behavior of Non-Rotating low-n MHD Instability to Collapse

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In LHD discharges, typically the 2 kind of low-n MHD instabilities driven by the pressure gradient, the rotating mode and the non-rotating mode, are observed [1]. Here 'n' is the toroidal mode number.

The rotating modes, which have several kHz frequencies, are observed for the wide range of the beta value, and the amplitude of the magnetic fluctuation increases as the beta increases and the magnetic Reynolds number decreases. In the high beta discharges, just the resonant modes with the peripheral rational surfaces are observed, which does not lead to any disruptive phenomena.

On the contrary, the non-rotating modes are characterized by the growth of the low-n perturbed magnetic fluctuation, which often leads to a collapse. The instabilities don't have real frequency and are often observed in the low magnetic shear configurations even in relative low beta range, $<\beta> < 1.5\%$. According to the calculation results by the linear MHD instability analyzing code, FAR3D [2] for the discharges with the collapse, the ideal MHD instability with the relative wide radial-mode-width, which has the finite amplitude of the displacement vector, are predicted. The radial mode structure predicted for the ideal interchange instability is relatively consistent with that estimated from the change of the electron temperature profile in the collapse. However, we should note that the non-rotating perturbed magnetic field is observed, which suggests the growth of the magnetic island (in the linear ideal interchange instability, the magnetic island isn't predicted), and that the growth time is ~100ms, which is much slower than that of the linear prediction.

In order to study the effect of the linear mode on the collapse, we investigated the fast response of the electron temperature profile during collapse. Figure 1 shows a typical discharge with the non-rotating MHD mode and the collapse. At t=1.96s, the collapse (the decrease of the beta value) starts and the perturbed magnetic field starts growing. Fig.1 (d) and (e) shows the fast response of the electron temperature by the ECE measurement. The electron temperature starts decreasing in the wide radial location simultaneously just after a rapid collapse (spike) of the core electron temperature. The rapid spikes are sometimes observed before the collapse. The typical time of the rapid spike is ~0.1ms, which is comparable with the growth time predicted by a linear theory. The reduction of the electron temperature in the spike is small (<10% of the core temperature). The profile of the rapid decrease of the electron temperature is not consistent with the radial profile predicted for the linear resistive interchange instability. We should make the non-linear calculation and compare it with the experimental results in order to identify the driving mechanism of the collapse due the non-rotating MHD instability.

[1] S.Sakakibara et al., Fusion Sci. Technol. 50 (2006) 177.
[2] L.Garcia, in Proc. 25th EPS Int. Conf. (Prague, Czech Republic, 1998) vol 22A, Part II p 1757 (1998).

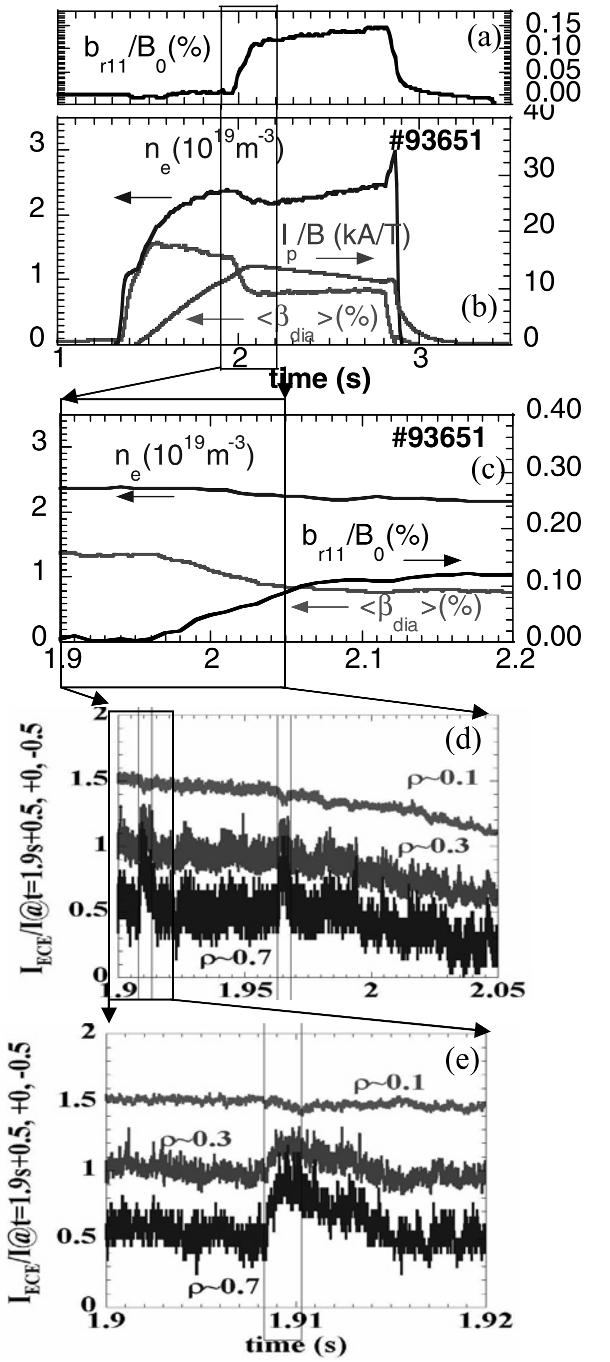

Fig. 1 The time evolution of the perturbed magnetic field (a,c), the electron density, the beta value and the net toroidal plasma current (b, c), and the electron temperature (d, e) in the discharge with the collapse.