§46. Mode Structure of Global MHD Instabilities and its Effect on Plasma Confinement in LHD

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The LHD magnetic field configuration is characterized by high magnetic shear with low magnetic well or magnetic hill particularly at the plasma periphery. In such LHD plasmas, magnetic hill persists near the edge even in high-beta regime where magnetic well is formed in most of the inner region. As a result, magnetic fluctuations due to the m=1/n=1 edge-resonant MHD instabilities are observed[1]. In these circumstances, we have observed fine structures in density and temperature profiles without leading to disruptive termination. In the present study, we have performed quantitative evaluation of the effect of the peripheral mode on the plasma performance.

An example of the effect of the peripheral MHD instability on the plasma confinement is shown in Fig.1. Figure 1(a) shows the time evolutions of discharge and plasma parameters. Time evolution of the beta value is obtained from the diamagnetic measurement. As shown in Fig.1(b), the m=1/n=1 magnetic fluctuation with the level of 0.01% disappeared during the discharge. The experimental energy confinement time is normalized to the ISS04 scaling value estimated at t=2s. Figure 1(b) clearly shows that disappearance of the magnetic fluctuation results in 10% recovery of the energy confinement time. The recovery was brought about by an increase in the edge electron temperature as shown in Fig.1(c). The electron temperature at rho=0.8 increased by ~25% when the magnetic fluctuation disappeared. We can conclude that the peripheral MHD instability whose edge magnetic fluctuation level is 0.01% has caused degradation of energy confinement by ~10%.

The degradation was caused by the MHD instability, and therefore, it is essential to obtain the relationship between the internal structure of the MHD instability and its effect on plasma confinement. The mode structure before the disappearance of the m=1/n=1 magnetic fluctuation was obtained from the soft-X ray (SXR) fluctuation. The SXR fluctuation component coherent with the m=1/n=1 magnetic fluctuation was extracted. The major radial profiles of the amplitude and phase of the m=1/n=1 SXR fluctuation indicate that the SXR fluctuation is localized near the ι=1 resonant surface, that the fluctuation is odd in poloidal mode mode number and that the phase does not change across the resonant surface. They are the characteristics of the pressure-driven instability which produces no current sheet on the resonant surface. The line integrated SXR fluctuation profile was converted to the radial profile using a Gaussian profile model peaked at the resonant surface. The mode width Δsx was defined from the Gaussian profile. In the case of Fig.1, we have concluded that the energy confinement has been degraded by 10% when the peripheral mode with normalized width of 5% exists.

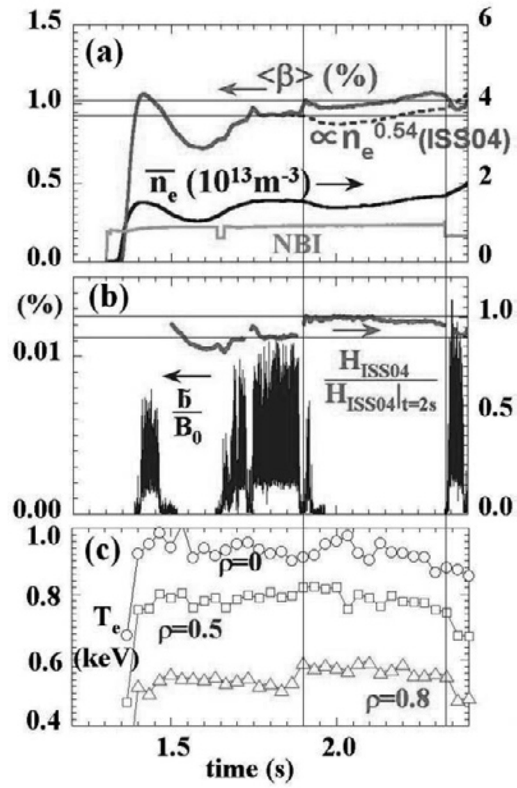

Fig.1: An example of confinement recovery accompanied by the disapperance of magnetic fluctuations due to the low-order peripheral m=1/n=1 MHD mode.

The experimental mode widths Δsx were compared with another mode widths Δcs which were calculated using the current sheet model as follows. A current sheet was assumed on the m=1/n=1 resonant surface and its amplitude was determined such that the edge magnetic fluctuation reproduced the experimental value. The magnetic island width was calculated using thus determined current sheet, and the island width was regarded as the mode width Δcs. The experimental mode widths are about 1/3 of what are expected from the current sheet model. The discrepancy represents the characteristic of the pressure-driven instability, and accumulation of the data would make it possible to compare them with the theoretical prediction of mode width of the pressure driven peripheral MHD instability.

[1] S.Sakakibara et al., Plasma Phys. Control. Fusion **50** (2008) 124014.
[2] Y.Takemura et al., Proc. 19th International Toki Conference, P1-37 (2009).