§18. MHD Activities in High-β Plasmas of LHD

Sakakibara, S., Yamada, H., Watanabe, K.Y., Narushima, Y.

In high-β experiments, a magnetic configuration with an inward-shifted R_{ax} of 3.6 m has been selected because neoclassical transport and particle confinement of high-energy ions are superior to the outward-shifted case. However, this configuration is unfavorable from the viewpoint of linear MHD stability. Theoretical prediction suggests that the high-n ballooning mode is unstable when the central beta is 8 % (peaked profile), and destabilization of the interchange mode becomes a major concern. The stability beta limits estimated by the low-n ideal mode analysis and the Mercier criterion are higher for the outward shifted plasma than the inward shifted case because of magnetic well formation. In previous experiments, the pedestal structure has been observed and has made a great contribution to global plasma confinement. However, the structure has formed large pressure gradient in peripheral region with magnetic hill and peripheral modes have been observed in low-β (high-field) plasmas. Here, observation results of MHD activities in high-β plasmas are reported.

The ι = 1 resonant modes in peripheral region and the n/m = 1/2 mode in core region have been dominantly observed in the $<\beta_{dia}>$ range with over 2 %.1) Figure 1(a) and (b) show the changes in fluctuation amplitudes of the ι = 1 resonant modes and n/m = 1/2 mode with $<\beta_{dia}>$ in 16 NBI discharges with R_{ax} = 3.6 m and $B_t \leq 1.5$ T. The β gradient at $\rho = 0.9$ and $\rho = 0.5$ are shown in fig.1(b) and (d), respectively. The ι = 1 resonant modes have been observed even in low-β region and the amplitude keep to increase with $<\beta_{dia}>$ and β gradient. The n/m = 1/2 mode appears when $<\beta_{dia}>$ reaches to 0.3%. Although the amplitude increases with $<\beta_{dia}>$, it saturates when $<\beta_{dia}>$ exceeds about 1.4 %. In the discharge with over 2 %, the n/m = 1/2 mode which may causes local flattening of Te profile near n/m = 1/2 resonant surface has been observed. The degradation of global energy confinement due to mode activity is a few %.

Figure 2 shows the unstable region of ideal n/m = 1/2 modes in the plane of $<\beta_{dia}>$ and β gradient at $\rho = 0.5$. MHD stability has been calculated by the 3-D MHD stability analysis code TERPSICHORE 2) for different pressure profile. The measured β gradient at $\rho = 0.5$, which approximately correspond to ι = 1/2 surface, fits that in the $P = P_0(1-\rho^2)^{0.5\sim1}$ cases. In this case, the present operational region is located in marginal against the low-n ideal instability and Mercier criterion predicts that the n/m = 1/2 mode is definitely unstable because of magnetic hill. While the ι = 1 resonant ideal modes are stabilized by strong magnetic shear, resistive modes are destabilized by magnetic hill because of no shear stabilization effect. Violent instabilities which terminate the plasma have not been observed so far.

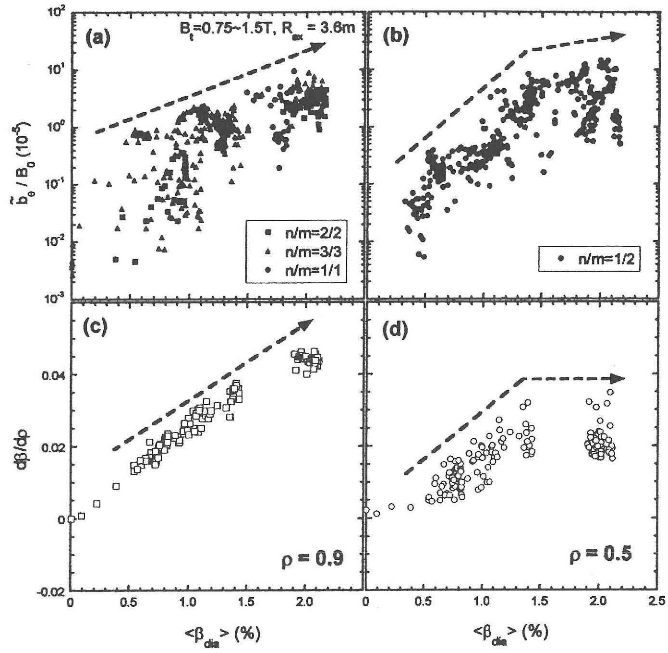

Fig.1. Changes in fluctuation amplitudes of ι = 1 resonant modes and n/m = 1/2 mode and β gradient at each resonant surfaces as a function of $<\beta_{dia}>$. Solid line corresponds to the temporal change in dβ/dρ in one discharge.

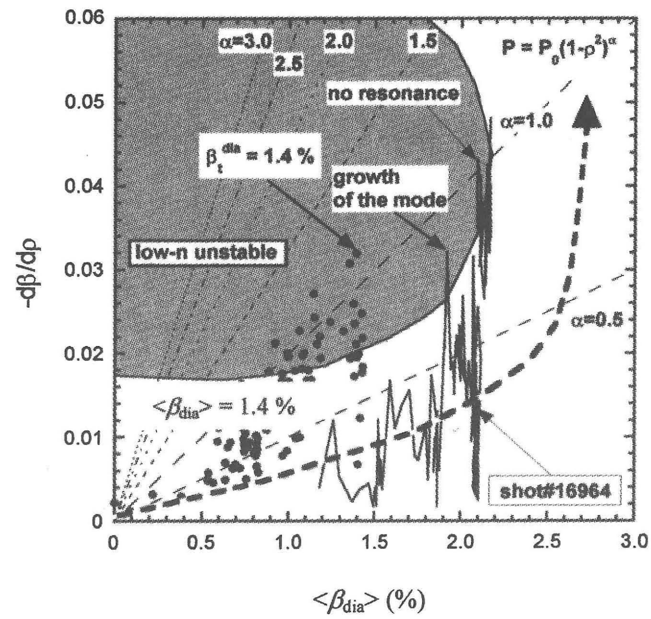

Fig.2. Unstable region of ideal n/m = 1/2 modes in the plane of $<\beta_{dia}>$ and β gradient at $\rho = 0.5$. Solid line corresponds to the temporal change in dβ/dρ in one discharge.

Reference
1) Sakakibara, S., et al., IAEA-CN77/EXP3/12
2) Cooper, W.A., et al., Plasma Pys. Control. Fusion **34** (1992) 1011.