# §19. Comparative Study of MHD Instabilities in LHD and JT-60U – Instability at $\iota$~0.5 during Counter-NB –

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**i) Introduction**

It is generally recognized that in helical systems Mercier stability increases with increasing plasma current in counter direction. However, an instability localized at $\iota/2\pi$~0.5 has been observed in LHD experiments with standard configuration ($B$=2.75 T, $R$=3.60 m, $\gamma$=1.25, $B_q$=100%). This research aims to clarify the characteristics of this instability and to compare with similar instabilities in tokamaks.

**ii) Experiments**

In the previous campaign, characteristics of the instability was investigated at $B$=2.75 T alone, where it was not clear whether the onset of the instability depends on $I_p$ or $I_p/B$ (~$\iota$). In this campaign, experiments were performed at $B$=1.32 T to discriminate between the $I_p$ dependence and the $I_p/B$ dependence. In the experiment, the instability was measured with magnetic probes and electron cyclotron emission (ECE) diagnostics. In addition, Mercier stability of an experimental result has been investigated using a computational code.

**iii) Results**

In this campaign, the following results has been obtained:

- When the direction of NB was switched from counter-direction (counter-NB) to co-direction (co-NB), no instability was observed even with large negative $I_p/B$ value. On the other hand, in the case of counter-NB after co-NB, the instability was observed shortly after the switch of the NB direction.
- Spatial structure and temporal evolution of the instability at $B$=1.32 T have been successfully measured with the ECE heterodyne radiometer. It was found that the instability is localized at $\iota/2\pi$~0.5, and its frequency is 1 to 2 kHz, as shown in Fig. 1. These are the same characteristics as those at $B$=2.75 T.
- The instability can be classified into the following three types: (a) sinusoidal oscillations, (b) sawtooth oscillations, (c) mixture of the sinusoidal and the sawtooth oscillations. The sinusoidal oscillations were observed at higher density ($\bar{n}_e > 0.8\times10^{19}$ m$^{-3}$) region, while the mixture oscillations were observed in low density ($\bar{n}_e < 0.6\times10^{19}$ m$^{-3}$) region.
- Stability analysis using experimentally obtained pressure profile and equilibrium shows that plasma becomes more stable when plasma current is increased in counter direction, as considered generally.

**iv) Discussion and summary**

It is found that temporal evolution and spatial structure of the instability for $B$=1.32 T shows the same characteristics as that at $B$=2.75 T. As for the onset condition, however, no clear tendency was found, while the dependence of $I_p$ was clearly observed for $B$=2.75 T. This result suggests that some parameters other than $I_p/B$ contribute to the mode onset.

Results from the NB switch-over experiments suggest that NB injection pattern and resulting change in current and pressure profiles destabilize the instability.

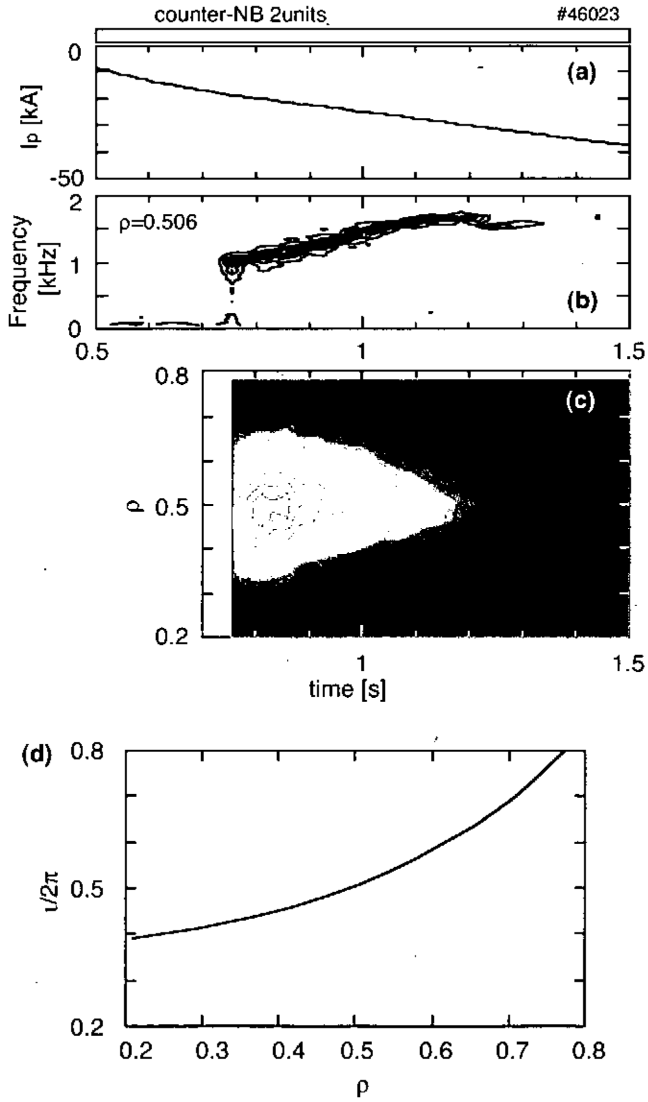


Fig. 1: (a) Plasma current, (b) spectrum of electron temperature perturbation at ρ=0.506, (c) contour plot of the electron temperature perturbation, (d) rotational transform profile.