§32. Observation of Localized Oscillations at m/n = 2/1 Rational Surface during Counter Neutral Beam Injection

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In LHD experiments, an instability localized at the $\iota/2\pi$=0.5 surface during neutral beam injection (NB) in the counter direction is observed. In this study, characteristics of this instability have been investigated. Stability analysis using profiles and equilibrium in an LHD experiment has been also performed.

Spatial structure and its evolution of the localized instabilities in LHD experiments have been investigated using the signals of magnetic perturbation and electron temperature perturbation profile from electron cyclotron emission (ECE) diagnostic. It has been found that electron temperature perturbations exist at $\iota/2\pi$=0.5 with the spatial extension of about 10% of the minor radius. The instability typically grows in several milliseconds and saturates. In a few discharges, the instability was triggered by a sawtooth crash. Under the condition of increasing plasma current in the counter direction and nearly constant pressure, the oscillations are observed at larger magnitudes of plasma current (–20 kA T^{-1}). In the NB reversal experiments, where the direction of the NB is changed from the co- to the counter-direction and vice versa, the oscillations were observed only for the former case. These results suggest that the profile and magnitude of the plasma current play an important role in the mode onset. According to the motional Stark effect diagnostic, rotational transform at $\iota/2\pi$>0.5 decreases while it increases at $\iota/2\pi$<0.5 when the direction of NB is changed from co- to counter-direction, showing that magnetic shear at the $\iota/2\pi$=0.5 surface decreases by the NB reversal. It is probable that the decrease in the magnetic shear at the $\iota/2\pi$=0.5 surface is responsible for the onset of the localized oscillations.

In addition to the experimental study, stability analysis has been performed. Analysis based on the Mercier criteria using the VMEC code shows that at a fixed plasma current an interchange mode becomes more unstable when the current profile is hollow (Fig. 1). It has been also found that for a flat or a hollow current profile the interchange mode becomes more unstable at higher negative plasma current while the stability is improved by increasing the plasma current for a center-peaked current profile. The result suggests that the center-peaked profile is not likely to occur during the counter-NB or NB reversal from co- to counter-direction, which is a similar tendency to the above experimental observations. It is also found that radial displacement due to the localized oscillations evaluated from electron temperature perturbation profiles with the ECE diagnostic agrees well with that predicted by a three-dimensional ideal magnetohydrodynamic stability code TERPSICHORE (Fig. 2).

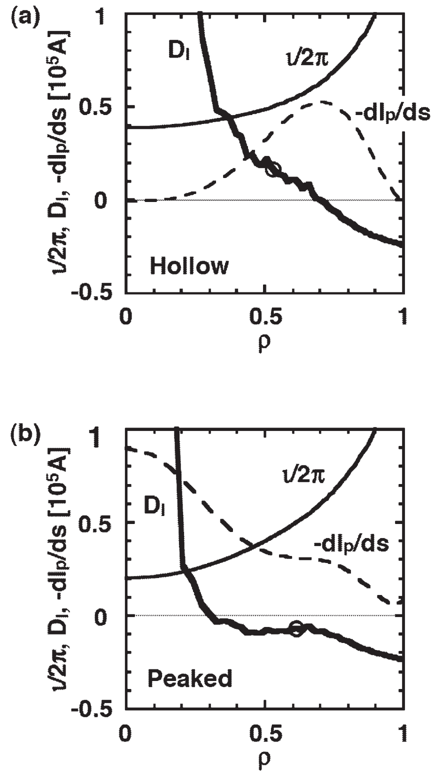

Fig. 1. Profiles of rotational transform ($\iota/2\pi$), the Mercier parameter (D_I) and current density ($-dI_p/ds$) for different current profiles: (a) hollow current profile and (b) peaked current profile. In each figure, the location of $\iota/2\pi$=0.5 is indicated on the D_I profile with an open circle.

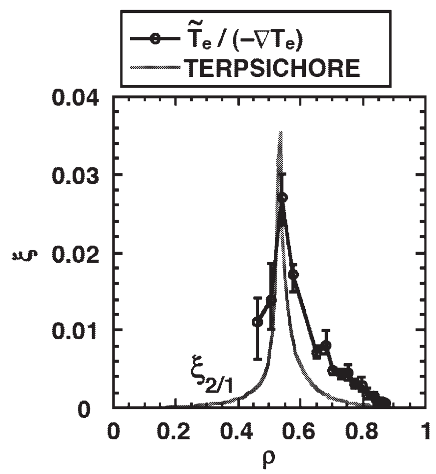

Fig. 2. Profiles of radial displacement evaluated from ECE measurements and TERPSICHORE calculations.

Reference

1) Isayama, A., Inagaki, S., Watanabe, K.Y., Narushima, Y., Sakakibara, S., Funaba, H., Ida, K., Nagayama, Y., Yamada, H., Kawahata, K., Komori, A., O. Motojima and LHD Experimental Group, Plasma Phys. Control. Fusion **48** (2006) L45-L55.