§2. Development of Real-time Control System of MHD Instabilities

Masamune, S., Nakamura, M. (Kyoto Inst. Tech.),
Takemura, Y. (Grad. Univ. Advanced Studies),
Watanabe, K.Y., Sakakibara, S., Narushima, Y.

In a series of experiments in LHD, the relationship between the internal mode width and external magnetic fluctuation has been made clear. We have shown that the normalized mode width (full width of half maximum of SXR emission intensity profile normalized to the plasma minor radius) and magnetic fluctuation level. In the region where magnetic fluctuation level lower than 0.01%, the mode width was estimated using the method in ref.1. The mode width of 5% estimated using the same procedure in the high magnetic fluctuation region agreed with the radial width of the flattened profile region of the Thomson scattering electron temperature. This suggests that the mode width is closely related with the magnetic island. Analyses have been performed of the mode widths in the region where magnetic fluctuation level is between 0.01% and 0.03%. The results show that when the external magnetic fluctuation level is 0.01%, the internal mode width is 5% of the plasma minor radius. Therefore, the experimentally measured magnetic fluctuation level of 0.01% corresponds to the internal edge mode whose radial width (of the eigenfunction) is 5% of the minor radius. If we could stabilize this particular mode, then we can expect that the confinement performance is improved by 10%. We have thus obtained quantitative relationship between the external magnetic fluctuation level and internal mode width. Thus it has become possible to estimate quantitatively the effect of internal mode on the plasma confinement characteristics. It has been observed experimentally that the m/n=1/1 edge mode structure has been modified such that the profile is flattened with inward shift of the maximum amplitude location from the corresponding mode resonant surface, as shown in Fig.1. This phenomenon appears to depend upon the magnetic configurations, and detailed condition under which the mode structure modification occurs has been studied intensively. Degradation of the beta value by 20% accompanies this modification.

Experiments have been carried out to study the response to the resonant magnetic perturbation of these mode structure change and associated confinement degradation. It is the first step to establish the active control method of these m/n=1/1 instabilities. In this series of experiments, the local island divertor (LID) magnetic field has been applied with a variety of intensity and polarity. The LID field intensity was changed from the level such that it cancels the intrinsic resonant perturbation field to the level such that the LID field can enhance the intrinsic magnetic island, up to the LID current of 2.5 kA/T. The results are summarized in Fig.2; The arrow shows the LID coil current which cancels the natural island (i.e., intrinsic resonant perturbation). It has been observed that the magnetic fluctuation level decreases as the external resonant magnetic perturbation is increased. In the case of ● in the figure, time-averaged electron temperature profiles show that the profile has meaningful gradient at the mode resonant surface, while in the case of ■, the temperature gradient disappears at the mode resonant surface. Detailed analyses have been carried out on the relation between the pressure gradient and magnetic fluctuation level, as well as on relation between the SXR fluctuation profiles and resonant perturbation amplitudes.

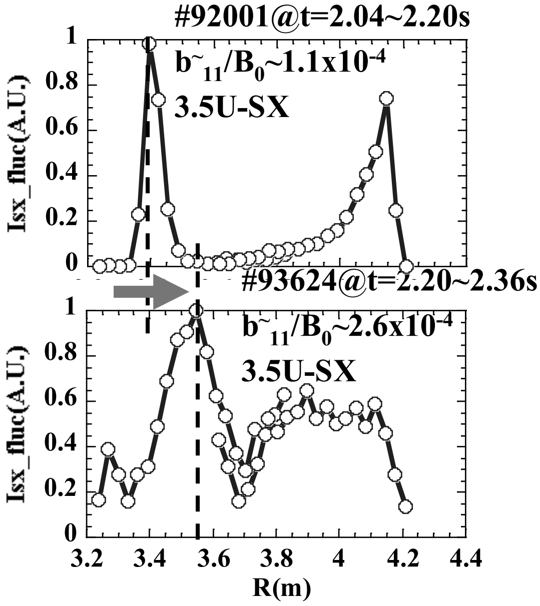

Fig.1. Typical m/n=1/1 mode structure (upper trace) and the same m/n=1/1 mode having modified internal structure (lower trace). The mode width increases with inner shift of the maximum amplitude location.

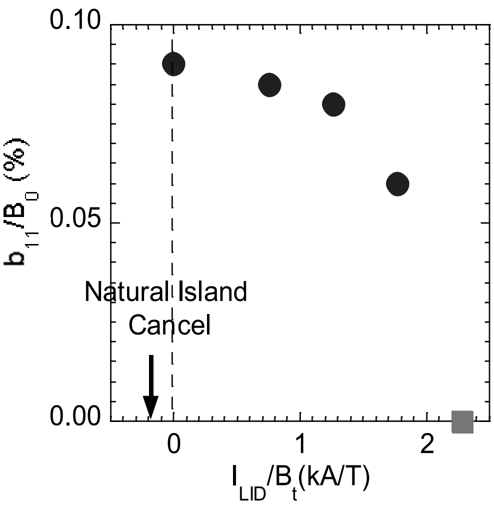

Fig.2. Dependence of magnetic fluctuation level on the external resonant , magnetic perturbation by LID coil. In the case of ■, significant flattening of the electron temperature profile occurs at the resonant surface location.