§11. Development of a Real Time Control System for MHD Instabilities

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In LHD, the most important instability is the resistive interchange mode arising from the magnetic hill configuration near the plasma edge. In fact, edge modes with low-mode number sometimes grow in a regime where beta > ~4%. The aims of this research include understanding the mechanism of growth and saturation of this mode, and designing a real-time control system for this particular mode as a part of the high-beta plasma research in LHD. As a first step, we started development of an MHD control system for high-beta plasmas of Reversed Field Pinch (RFP) configuration in a low-aspect-ratio RFP machine RELAX[1,2]. In the RFP configuration, current-driven tearing or kink instabilities are the most important. Figure 1 shows a schematic diagram of the active MHD control system for the RFP.

In order to understand the relation between the m=1/n=1 mode amplitude and associated magnetic island width of high-beta plasmas in LHD, the following analysis has been performed[3]. A model magnetic island width $W_{1,1}$(model) is calculated using the formula based on the tearing mode with a model perturbation current due to the m=1/n=1 mode in simplified LHD configuration. The edge magnetic field due to this perturbation current is also calculated. The experimental magnetic island width $W_{1,1}$(Thomson) is estimated from the electron temperature profiles measured with Thomson scattering diagnostic. $W_{1,1}$(Thomson) is defined as the width of flat-temperature region near the m=1/n=1 resonant surface. Figure 2 compares $W_{1,1}$(model) and $W_{1,1}$(Thomson) for the measured amplitudes of the m=1/n=1 mode. As seen in the figure, the agreement is not satisfactory. Both elaboration of the modeling and analysis of the experimental ECE data to estimate the magnetic island width are in progress.

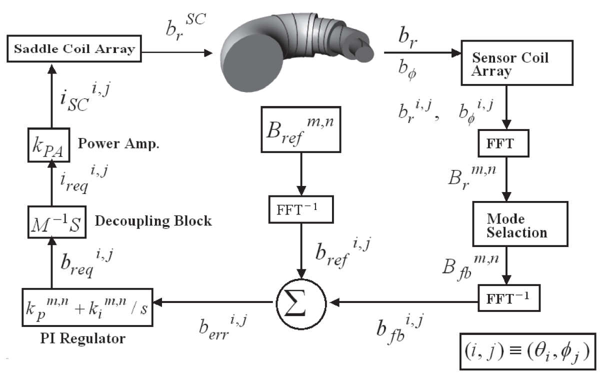

Fig.1: Schematic diagram of the control system for RFP.

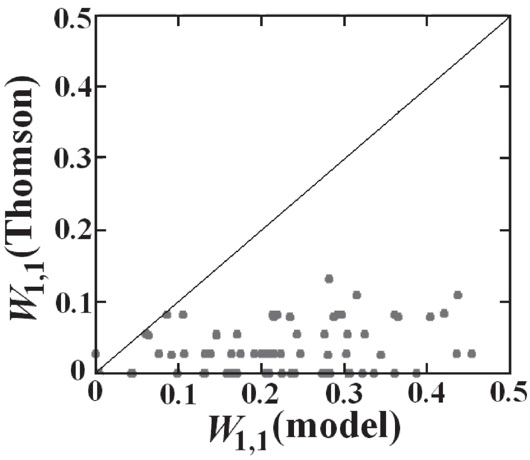

Fig.2: Comparison of the experimental and model magnetic island widths for the measured amplitudes of the m=1/n=1 mode in LHD.

Comparative studies of the MHD characteristics of high-beta plasmas in RFP and in LHD constitute another part of this research. Some arrays of pick-up coils have been installed in RELAX (as sensors) and the mode spectra of the edge magnetic fluctuations are obtained under various discharge conditions. Time evolution of the amplitudes of m=1 modes in a round-topped discharge in RELAX shows that quasi-periodic growth of a single resonant mode (m=1/n=4) is observed over most of the discharge duration[4]. The toroidal mode spectrum near the m=1/n=4 mode amplitude maximum has the characteristics of the quasi-single helicity (QSH) RFP state with higher amplitude level than in other RFPs. The higher level of the amplitude of single dominant mode might be attributed to the resistive wall boundary condition of RELAX, under which saturation level of the tearing mode can be higher than ideal wall condition. In the extreme case, a large-scale change in magnetic field profiles is observed in self-reversal operation mode. The resultant magnetic field configuration looks like the Helical Ohmic Equilibrium state[5], which is essentially a non-planar-axis helical equilibrium with toroidal field reversal.

1) Masamune, S. et al.: J. Phys. Soc. Jpn. 76 (2007) 123501.
2) Onchi, T. et al.: Plasma Fusion Res. 3 (2008) 005.
3) Takemura, Y.: Bachelor Thesis (Kyoto Inst. Tech.) Feb. 2008.
4) Ikezoe, R. et al: Plasma Fusion Res. 3 (2008) 029.
5) Oki, K. et al.: J. Phys. Soc. Jpn. 77 (2008) in press.