§2. Effect of Active Control on Plasma Performance in Magnetically Confined Toroidal Plasmas

Masamune, S., Himura, H., Sanpei, A. (Kyoto Inst. Tech.),
Takahashi, T. (Gunma Univ.), Kanki, T. (JCGA),
Asai, T., Takahashi, T. (Nihon Univ.),
Inomoto, M., Ono, Y. (Univ. Tokyo),
Nagata, M., Fukumoto, N., Kikuchi, Y. (Univ. Hyogo),
Mizuguchi, N., Narushima, Y.

In high-beta toroidal plasmas such as Spheromak (SP), Field Reversed Configuration (FRC), Spherical Tokamak (ST), and Reversed Field Pinch (RFP), various methods for active control have been applied to realize improvement of plasma performance or to control plasma dynamics during MHD relaxation. We can list up the methods such as magnetic helicity injection for current profile control, neutral beam injection for heating or density profile control, inductive current drive for current density profile control, magnetic boundary control for MHD stability manipulation, Compact Torus (CT) plasma injection for helicity injection, and so on.

In this research program, new collaborative experiments and theoretical works have been started. The machines involved in these experiments are HIST (SP) at Univ. of Hyogo, NUCTE (FRC) at Nihon U., TS-3 and 4 (SP, FRC, ST) and UTST (ST) at Univ. of Tokyo, RELAX (RFP) at KIT, and LHD at NIFS, with research topics related to active control. Theoretical works related to these collaborations include particle simulation at Gunma Univ., 3-D MHD simulation at NIFS, two-fluid MHD equilibrium and stability analysis at JCGA..

There follows a list of topics of collaborative research programs which has been initiated by the review trips made in the previous FY 2011.

- U-Tokyo - Nihon U: CT injection to FRC plasmas for stabilizing rotational instabilities in high-beta FRC configuration. The experiments have been performed in NUCTE device. Construction of multi-chord Doppler spectroscopy diagnostic system has been started Doppler for the study of spontaneous rotation measurement in NUCTE machine.
- U-Hyogo - Nihon U - KIT: Design study for CT injection to RELAX machine has been started. Reduction of poloidal magnetic flux consumption in current rise phase would be expected with the help of magnetic helicity injection (equivalent to pararrel current drive) and additional heating to reduce plasma resistivity, which would contribute to reduce both the inductive and resistive loop voltage in the current rise phase in RELAX.
- U-Hyogo - U-Tokyo: Comparative experiments have been started among TS-3, TS-4, and HIST machines on the MHD waves excited at CHI/reconnection and their effects on current drive efficiency as well as plasma confinement.
- Gunma-U - Nihon-U: Experiments on fast transfer of FRC in neutral gas cloud, equivalent to NBI injection for the FRC plasma, has been performed. The results have been compared with the particle simulation results to discuss conditions for equivalent NBI heating and spontaneous flow generation in FRC configuration.
- CGA - U-Hyogo: Measurement of plasma flow and electric field during multi-helicity injection to HIST machine has been performed. Comparison of the results with 3-D MHD simulation and 2-fluid equilibrium analysis has been in progress.
- KIT - NIFS: 3-D MHD simulations have been performed using the MIPS code. Dynamics of the low-A RFP plasmas in relaxation phase to helical RFP state has been studied; the role of resonant and non-resonant modes are being made clarified depending on the initial equilibrium configuration.

The outcomes of this program have been presented at US-Japan MHD Workshop, EPS Conference, US-Japan CT Workshop, IAEA Fusion Energy Conference, Annual Meeting of JSPF, and so on. An example of the results is shown in Fig.1, where helical RFP states from experiment (SXR emissivity profile) and from MHD simulation (equi-pressure surfaces) are comparatively shown. It has been confirmed in MHD simulation that the helical state could be triggered by both a core-resonant tearing mode and an internally non-resonant kink mode. In both cases, magnetic field lines in the helical core region look somewhat stochastic, which may imply the importance of the secondary modes even with low amplitudes. Detailed analysis of the relaxation process is in progress by comparing the experiments and simulations.

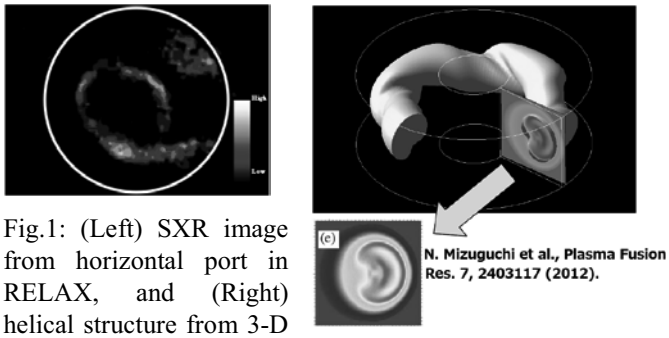

Fig.1: (Left) SXR image from horizontal port in RELAX, and (Right) helical structure from 3-D MHD simulation. The helical magnetic axis corresponds to the experimental SXR image