§3. Observation and Control of Self-governing Events in Compact Torus Plasmas

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1. Objectives

High-beta torus plasmas generally have larger internal plasma current ratio than helical and tokamak systems and exhibit a variety of self-governing events and non-MHD phenomenon, for example, self-organization, two-fluids effect, particle acceleration and so on. Verification of these events could contribute to wide research field on basic plasma and also on future burning plasma physics. In addition, application of small-scale plasma experiments in industrial or medical fields are rapidly progressing. This network collaboration program promotes collaborative research among small-scale and high-beta plasma studies performed in university research groups to enhance their research efficiency and to develop young human resources.

2. Results

Seven collaborative research subjects regarding high beta compact torus plasmas such as spheromak (SPH), field-reversed configuration (FRC), reversed field pinch (RFP) and spherical tokamak (ST) have been promoted among four groups performing experimental studies (Univ. Tokyo, Univ. Hyogo, Kyoto Inst. Tech., Nihon Univ.) and three groups performing theoretical/numerical studies (Gunma Univ. JCGA, NIFS). Individual achievements are described below.

(1) CT injection for helicity injection and fuelling (Nihon-U., U. Tokyo)

Joint experiments on CT injection have been performed in Nihon U. and U. Tokyo using NUCTE (FRC) and UTST (ST) devices. In NUCTE experiment, two end-on CT injectors were utilized to supply magnetic flux to FRC plasmas. New experimental findings which suggest flux amplification mechanism due to the enhancement of radial pressure gradient given by CT injection were achieved. Another CT injection experiment aimed at fueling was newly started. CT injector developed in Nihon U. was moved to U. Tokyo Kashiwa campus and connected to UTST device. First injection experiment was performed and preliminary data for CT injector optimization were achieved.

(2) Translation and spontaneous rotation of FRC (Nihon U. and Gunma U.)

Simulation codes on FRC translation and spontaneous rotation observed in NUCTE experiment have been developed in Gunma U. They introduced experimentally-based conditions to their simulation codes and suggested more effective translation method and novel rotation mechanism.

(3) Soft X-ray emission in magnetic reconnection events (Kyoto Inst. Tech., U. Tokyo)

Soft X-ray measurements using SBDs and AXUV photodetectors have been developed in Kyoto Inst. Tech. and U. Tokyo to observe magnetic reconnection events in RELAX (RFP) and UTST (ST) plasmas. Preliminary experimental results showed that soft X-ray burst was induced synchronously with the enhancement of reconnection electric field, suggesting generation of non-thermal electrons by parallel electron acceleration.

(4) Theoretical and experimental approach for two-fluids effects (Kyoto Inst. Tech, JCGA, Hyogo U.)

Two fluids equations were applied to interpret non-neutral plasma experiment performed in BX-U. Two fluids description of multi-pulsed helicity injection to ST plasma were developed in JCGA and those numerical results were compared with experimental results obtained in HIST experiment in Hyogo U. The origins of density gradient steepening, flow shear enhancement, and radial electric field enhancement were investigated.

(5) Novel D-^{3}He reactor concept (Gunma U., Kyushu U.)

Fusion reactor concept using a new high-beta configuration of diabatic trap was suggested. Equilibrium calculation and evaluation of 14.7MeV proton confinement were carried out. Precise D-^{3}He burning characteristics are under analysis using nuclear elastic scattering is in progress.

(6) Coaxial helicity injection for spherical tokamak start-up (Hyogo U., Kyushu U.)

In advance of the coaxial helicity injection start-up experiment which will be performed in QUEST, exchange of opinions between QUEST and HIST staffs were carried out. Injector design and start-up scenario were compared and improved.

(7) Numerical research of FRC merging formation (NIFS, U. Tokyo)

Cylindrical Hall MHD simulation code was developed to investigate asymmetry induced by the Hall effects and a radial electric field during merging formation of FRC plasmas.

3. Acknowledgements

This collaboration has greatly promoted joint research projects conducted mainly by young researchers and students. It provided good opportunities for students (total 42 person-days) to be involved in different research environment.