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

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1. Objectives

High-beta compact torus (CT) plasmas such as spheromak (SPH), field-reversed configuration (FRC), reversed field pinch (RFP) and spherical tokamak (ST) 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 physics, fusion plasma engineering, 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

Collaborative subjects in three categories such as (a) application of CTs, (b) development of CT diagnostics, and (c) theoretical/numerical studies on CTs, have been carried out among five groups performing experimental studies (U. Tokyo, U. Hyogo, Kyoto Inst. Tech., Nihon U., Kyushu U.) and four groups performing theoretical/numerical studies (Gunma U., Hokkaido U., JCGA, NIFS). Individual achievements are described below.

(a) <u>CT application (Nihon U., U. Tokyo, U. Hyogo, JCGA, Gunma U., Osaka U.)</u>

(a-1) Joint experiments on CT injection have been performed in U. Tokyo in collaboration with Nihon U. A CT injector developed in Nihon U. was relocated to UTST device in U. Tokyo to examine its performance on fueling spherical tokamak plasmas with toroidal magnetic field B_0 ~ 0.25 T at their magnetic axis. In tangential injection case, the injected CT was deflected form its original orbit and moved away from the main ST plasma possibly due to the electromagnetic force between toroidal field and CT's plasma current. On the other hand, penetration into the main ST was established in radial injection case. Fast camera observation showed that the injected CT plasma spread along the magnetic field lines before it reached the magnetic axis. It was found that the injection velocity was not high enough to overcome the increasing magnetic field pressure.

(a-2) Numerical model which interprets multi-pulsed helicity injection to ST plasma was developed in JCGA in collaboration with U. Hyogo. The relation between poloidal flow and toroidal field direction was investigated in simulation and experimental results.

(a-3) In order to improve the plasma source performance in a neutral beam injector, a rotating-magnetic-field-driven FRC has been developed in Nihon U. in collaboration with U. Tokyo. Here, new concept of three-phase rotating magnetic field was employed to improve power supply efficiency.

(a-4) Novel current drive and additional heating methods have been developed in NUCTE device in Nihon U. in collaboration with Gunma U., U. Tokyo and Osaka U. A new confinement chamber for low frequency wave heating was designed and fabricated.

(b) <u>Diagnostics (U. Tokyo, Kyoto Inst. Tech, Kyushu U., Hokkaido U.)</u>

(b-1) Soft X-ray tomography system has been developed in U. Tokyo in collaboration with Kyoto Inst. Tech. to observe electron acceleration/heating during magnetic reconnection events in UTST. It was found that intense soft X-ray emission was generated from the X-point region, indicating that the parallel acceleration of electrons might be localized inside the current layer.

(b-2) UV emission measurement system developed in Kyushu U. was relocated to RELAX device in Kyoto Inst. Tech. to observe plasma turbulence. UV and visible light emission measurement was carried out and their analysis scheme was under development.

(b-3) To develop a precise magnetic surface reconstruction method for ST and low aspect ratio RFP, a modified Cauchy condition surface (CCS) scheme was applied to UTST (in U. Tokyo) and RELAX (in Kyoto Inst. Tech.). Implementation and calculation methods were developed in collaboration with Hokkaido U.

(c) <u>Theoretical/numerical studies (Gunma U., Kyushu U.)</u>

(c-1) Conceptual design of a novel fusion reactor concept was developed by using non-adiabatic trap. D-3He ST reactor design was also carried out based on an inelastic collision and axial merging for fueling.

(c-2) Electron acceleration during magnetic reconnection with high guide field was investigated in experiment (in U. Tokyo) and numerical simulation studies (in NIFS). As well as parallel acceleration by reconnection electric field, perpendicular acceleration by charge separation was investigated.

3. Acknowledgements

This collaboration has greatly promoted joint research projects conducted mainly by young researchers and students. It provided good opportunities for students to be involved in different research environment.