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Control of Field-Reversed Configuration via Translation Process
移送法によるFRCプラズマのパラメータ制御

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A field-reversed configuration (FRC) can be easily translated along the axial guide field, because of their simply connected structure, and the translation speed, which can be controlled by the profile of guide magnetic field, reaches the range of Alfven speed. On the other hand, additional heating and current driving technique are not established yet, therefore the temperature and density of the FRC have been attempted to control by injecting the FRC into a neutral particle atmosphere. Also the aspect of FRC has been tried to modify to oblate shape via translation into large-bore translation chamber.

1. Introduction

A field-reversed configuration (FRC) plasmas formed by field-reversed theta-pinch (FRTP) method has a limited confinement lifetime of the order of micro-seconds. Therefore, formed FRC is translated into a confinement region with static field in the most of scenarios of FRC based fusion reactor to apply additional heating and current drive by neutral beam injection (NBI). In this work, this translation process has been tried to utilize to control FRC parameters and aspect.

2. Experimental Device

Nihon University Compact Torus Experiment (NUCTE)-III is a theta-pinch type FRC device[1]. It consists of a set of theta-pinch coils and quartz discharge tube that the external diameter is 256mm and the length is 2.0m. The FRC is formed with the bias magnetic field of -0.032T and the main magnetic field of 0.5T with the rise time is 4μs.

Translation region with a quasi-steady state confinement field named NUCTE-T has recently been constructed and connected to the NUCTE-III[1]. It consists of a quartz discharge tube of 0.4m in O.D. and 1.4m in length. The quasi-steady magnetic field is 0.06T with the rise time of 13ms. The schematic view of NUCTE-III/T is shown in Fig 1.

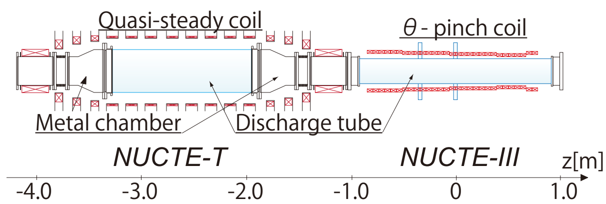

Fig.1. A schematic view of NUCTE-III/T

The discharge tubes are made of transparent quartz. Therefore optical measurements can be arranged flexibly from all angles and positions on the chamber. Basic diagnostics on the translation region consist of magnetic probes, flux loops, optical collimater arrays and a He-Ne laser interferometer.

3. Translation into Background Neutral Gas

Translation experiments of FRC into a translation chamber filled with neutral gas has been performed on NUCTE-III/T facility. This experiments has been tried to demonstrate “equivalent neutral beam injection (NBI)” effect of background gas onto the translated FRC. The filled background gas is injected into the translated FRC with relative velocity. Therefore, it makes large current low energy axial NBI effect on the FRC[1].

For background gases, deuterium, helium and argon have been chosen in this series of experiments. Figure 2 shows the time evolution of maximum separatrix radius r_s. Here the curves of r_s are tracing maximum radius of translated FRC. Figure 3 shows the time evolution of bremsstrahlung observed along a chord passing through the z axis indicating toridal deformation by rotational mode instability.

In the case of helium and deuterium, the configuration lifetimes estimated from the time evolution of r_s are prolonged compared to the standard operation case from 100 to 110μs.

As show in Fig. 3, onset time of toroidal deformation is also delayed by existence of background neutral gas. In the case with helium gas puffing, the onset is delayed 60μs compared to the case without gas fill.

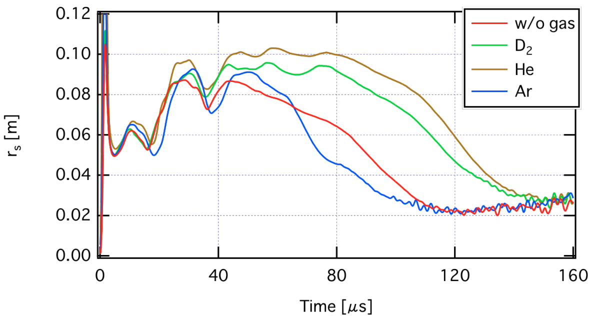

Fig.2. Time evolution of maximum value of separatrix radius.

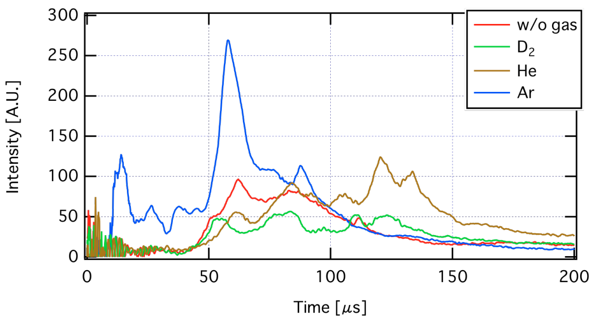

Fig.3. Time evolution of bremsstrahlung.

4. New Confinement Device

For faster translation velocity and to achieve high aspect ratio (i.e. oblate) FRC, new confinement region named FAT (FRC Amplification via Translation/Transformer) has newly been constructed. The FAT has a quartz discharge tube of 0.8m in O.D. and the 1.0m in length. The quasi-steady magnetic field is 0.08T with the rise time of 49ms One of the experimental purpose of FAT is modification of separatrix shape of theta-pinch based high density FRC into an oblate one through the translation process. The global stabilities of FRC plasmas depend on their aspect ratio, therefore the global instabilities are verified on FAT FRC experiments.

In the case of translation experiment into NUCTE-T, the prolonged confinement lifetime is within the order of a few hundred micro-seconds. In order to extend confinement lifetime, additional current drive is necessary. In the concept of D-^{3}He fusion reactor "ARTEMIS"[2], Neutral Beam Injection (NBI) is schemed as additional heating method, but the current stage of experimentally formed FRC plasmas have not achieved enough poloidal flux to apply NBI. For example, 20-30keV hydrogen ions require flux on order of 20mWb for NBI [3]. In the translated FRC plasmas into NUCTE-T have less than 0.1mWb of poloidal flux at total temperature 40keV[3]. Therefore a center solenoid is employed to build-up poloidal flux on FAT FRC experiments.

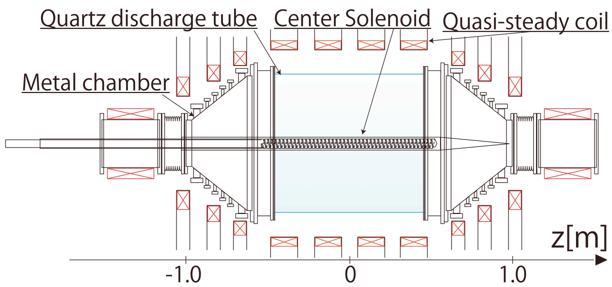

Fig.4. A schematic view of FAT.

Acknowledgments

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