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Internal structure of a field-reversed configuration plasma in translation process
移送過程における磁場反転配位プラズマの磁気構造

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Time evolutions of poloidal magnetic field structure and flux of a field-reversed configuration in a translation process have been investigated in NUCTE-III/T facility. One of the purposes for this study is to revel the relation between the time evolution and a translation speed. The translation velocity has controlled using a pair of assist coils installed in the translation region. The FRC plasma has been simulated as a set of several ring currents including induced current rings as a metal boundary and the poloidal magnetic structure and flux have been estimated. Preliminary experimental results will be presented.

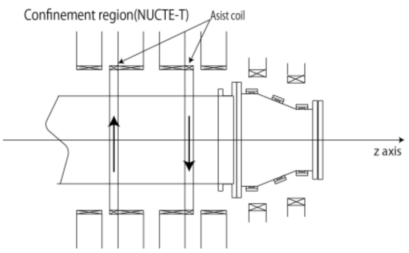
1. Introduction

A field-reversed configuration (FRC) plasma belongs to a compact troid (CT), which is a toroidal magnetic system confined by only a poloidal field and no or little toroidal magnetic field. [1]. The FRC has very extremely high beta value. The poroidal confinement field (B_{ze}) consists of the magnetic fields of an external coil (B_{z0}) and a self magnetic field of toroidal plasma current ($I_{p\theta}$). Since this plasma is an axial symmetric, liner, simple connected plasma and no link with the external coil system and another component structure, FRC plasma is able to translate along the confinement field.

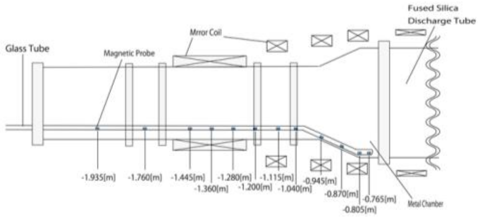
Recently, supper alfven translation trapping [2] and collision and marging [3] experiments have been performed, and improved ploidal flux confinement properties, increases of the poloidal flux and the rethermalization efficiency, a toroidal field generation, and a flux conversion have been observed. The development of these phenomena has related with a translation speed (supper alfven speed) and processes of a relaxation and self-organization of FRC plasma [4].

The Nihon University Compact Troid Experiment III/ Translation (NUCTE-III/T) device has been constructed and translation-trapping experiments have started [5]. One of the purposes for the research is to revel the time evolution of the poloidal magnetic field structure and the poloidal flux in the translation-trapping process. Since this process is a transient time evolution, it is difficult to apply an equilibrium model and solution of the Grad-Shafranov equation. In this study, the FRC plasma has been simulated as a set of several ring currents [6]. The conducting boundary (the metal chamber) and FRC are simulated as a set of ring currents. Here, the parameter of the ring currents (positions and strengths) is determined for the experimentally observed magnetic field density and flux. Then, the magnetic flux surface of the FRC plasma is estimated, including the effects of the metallic chamber.

In this paper, to investigate a time evolution of separatrix structure in the reflection process of the downstream mirror coil, an array of 12 magnetic probes has been inserted in the mirror coil region. A pair of pulsed coils has been also installed in the translated region (confinement region) to control of

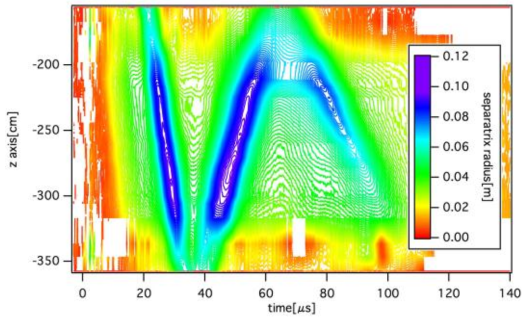


(a)

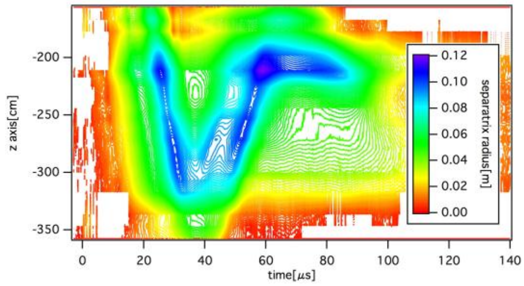


(b)

Fig.1 (a) Asist coil inserted in comfinement region and (b)magnetic probe array installed in downstream mirror field region.



(a)



(b)

Fig. 2 Time evolutions of excluded flux radius: (a) without the assist coil, (b) with the assist coil

the translation speed and preliminary experiments have been performed.

2. Experimental apparatus and diagnostic

The experiments have been curried out by the NUCTE-III/T device, which the details of the device have been described in the reference of [5]. The Figure 1 shows the schematic of a pair of assist coils installed in the confinement region of NUCTE-III/T (a) and the inserted magnetic probe array in the downstream mirror region (b). The axial motion of FRC plasma and magnetic structure is monitored by an excluded flux method of fourteen pairs of magnetic probe and magnetic flux loop and the newly inserted array of 12 magnetic probes and two arrays of 3 magnetic probes installed in up and down stream mirror region [6]. These magnetic data uses in the reconstruction of magnetic structure.

3. Preliminary experimental results

The time evolution of the FRC in the confinement region is shown in Fig. 2. The contour indicates the time evolution of $r_{\Delta\phi}$. At the first pass, the FRC rapidly decompressed to a volume four times larger than that in the formation region. The plasma accelerated to a velocity of 150 km/s and was then reflected at the downstream mirror with a mirror ratio of about three. At this point, the

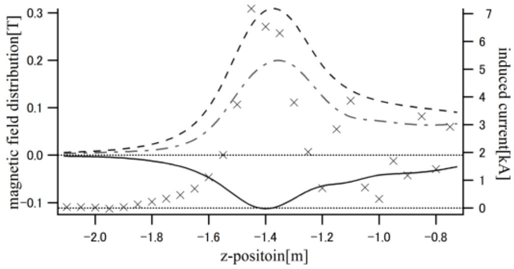


Fig.3 Estimated external coil field (dashed line), confinement field (chain line), induced current in vacuum chamber (×) and magnetic field of induced current (solid line).

translated velocity decreased to 90 km/s. After three reflections, the translation speed decreases to about 50km/s and the plasma entered a static phase. When the assist coil is applied, FRC plasma has been trapped between the assist coil and upstream mirror coil at third pass. By the assist coil, magnetic hump of mirror ration of 1.25 and magnetic countor of the ration of 0.8 have been produced in the confinement region. At the first and second passes, the translation speed is decrease and increase of 10% at backward and forward of the coil, respectively.

Magnetic field density strengths of the reflection region ($-2.0<z<-0.8$) produced by external coil and induced current in the metal chamber are shown in Fig. 3, which are estimated by 28 ring currents of the induced current. Its current profile in the metal boundary is shown in the same figure. The estimated time is just before the FRC injection. But time evolution of the plasma current, after the injection of FRC, doesn't have yet been obtained. In near future, the current profile of the FRC plasma and magnetic field structure in the reflection process will be revealed.

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