§22. Characteristics of High-Beta and High-Elongation Spherical Tokamak Like Field-Reversed Configuration

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A field-reversed configuration (FRC) has been known as an extremely high-beta compact toroid which is confined purely with poloidal magnetic field. It has been reported that the FRC plasma with modestly added toroidal magnetic flux relaxed into the ST like configuration with high-beta value and high q value in the vicinity of geometrical axis[1].

The established formation method of the ST like FRC is limited to the spheromak merging. To investigate the property of the ST-like FRC especially transited from high-beta FRC side, a new facility of FRC translation experiments, FAT (FRC Amplification via Translation) has begun operations. FAT has an extremely large-bore confinement chamber. The first plasmas on the FAT experiment are successfully translated without disruption even through the violent process of translation into the low aspect-ratio chamber (low length-to-diameter ratio).

Figure 1 is a schematic of the FAT facility. An FRC formed in the FRTP section is expelled by the magnetic field gradient. The most striking feature of the FAT experiment is the difference between the aspect ratio of the FRTP source and the confinement chamber. Despite this dramatic change, the translated plasmoid becomes a quiescent FRC without disruption.

FRC translation has been applied on several other facilities, which produce globally stable FRCs. In the other facilities, the confinement region had moderate to high aspect ratio (length / diameter of device), e.g. 13 in FRX-C/T[2], 3.8 in FIX[3] and 3.5 in C-2[4]. On the other hands, the aspect ratio is 2.3 in FAT, which is its most unique feature. Here, the elongation is defined as ratio of length to diameter of separatrix. Theoretically, an external tilt instability in low-elongation FRCs has been studied [5]. However, disruptive tilt instability has not been observed on FRC

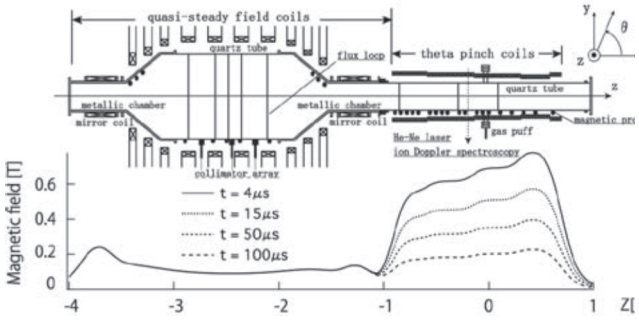

Fig. 1. Schematic view of FAT facility with positions of the installed diagnostics and the typical magnetic field profile

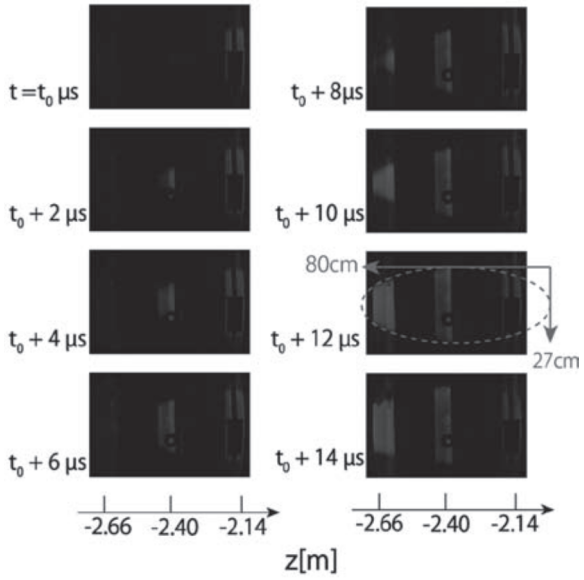

Fig. 2. Image of translated FRC taken by a visible light fast camera.

experiments including FAT experiment.

A visible light fast camera (Nac Image Technology Inc. / ULTRA Cam HS-106E) is used to capture the global behavior of the translated FRC. The elongation (separatrix (length / separatrix diameter) of the translated FRC is estimated from the fast-camera pictures experimentally, because the excluded flux method neglects the significant edge region of the FRC.

Figure 2 shows images of the translated FRC into an atmosphere of statically filled D_2 gas. The elongation of the translated FRC is approximately 3 estimated from the image by fast camera. In this operational condition, translation speeds are in the range between 70 to 100 km/s. The rotational instability with toroidal mode number n = 2 deformation has not been observed in this case.

A new FRC facility FAT has begun the operations. The FRC is translated with super-Alfvénic velocity of approximately 200km/s at the fastest case without disruption. The translation speeds could be controlled in the range between 70 to 210 km/s. FRCs translated with relatively slow speed of 70 to 100km/s do not survive the reflection from the downstream mirror coil. Evidently the translation speeds strongly affect the rebound process. The typical elongation of the translated FRC is approximately 3 estimated from the image by fast camera. These results indicate the possible application of the center stack into the FRC translation region.

This study was supported by NIFS under contract No.NIFS13KBAP017.

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