

§28. Study on Heating and Sustaining of FRC Plasma by Ion Ring Injection

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A field reversed configuration (FRC) has intrinsic features, i.e. pure poloidal magnetic field confinement, open field configuration outside the separatrix of plasma, and extremely so high plasma beta as more than 0.9.

These features are the high potential of FRCs for the fusion burning plasma, especially in D-³He fuel cycle reactors. Due to the features, on the other hand, conventional methods are not available technically for the sustainment of the configuration (heating of plasmas and supply of reversed magnetic flux) and for further heating of plasmas up to the temperature range of the fusion burning in FRCs.

An axial injection method of pulsed intense ion beams (or ion rings) were proposed for the configuration sustainment and the further heating in this study and its actualization has been investigated. It is planned to experimentally test the actualization on FTHX (FRC Transport and Heating Experiment, Osaka Univ.) device.

As showed in Fig.1., the devise consists of 3 parts (pulse ion beam diode, beam drift tube, and formation area of target plasma). Details of the diode are seen in Ref. 1. Expected parameters of the ion diode are as follows;

beam energy : 50kV, beam current : 2kA,
output power : 100MW, output energy : 1kJ.

The main purpose of FTHX is to investigate transport mechanisms in FRC plasmas. In our study on the transport, a following scaling of plasma confinement was obtained¹⁾;

$$h = (1 + 1.2 \times 10^3 \left(\frac{2r_s}{l_s} \right)^{2.7}) = (1 + 1.2 \times 10^3 \epsilon^{-2.7})$$

where h is a kind of confinement anomaly-parameter and a ratio of the confinement time inferred from 1-D classical MHD transport calculation to experimental confinement times (decay times), and where $\epsilon = l_s/r_s$, l_s is plasma length and r_s is radius. In a case where plasma is so extremely prolate as plasma aspect ratio of $\epsilon = 15 \sim 20$, therefore, confinement times obtained in experiments are 1-D classical and are $(0.3 \mu s^2 / 4\eta_0)$, where η_0 is Spitzer's resistivity²⁾. This scaling indicates that the confinement in FRCs is basically classical and degrades as ϵ becomes smaller due to 2-D transport effect.

In order to experimentally verify the dependence of the confinement time on ϵ and electron temperature T_e , the

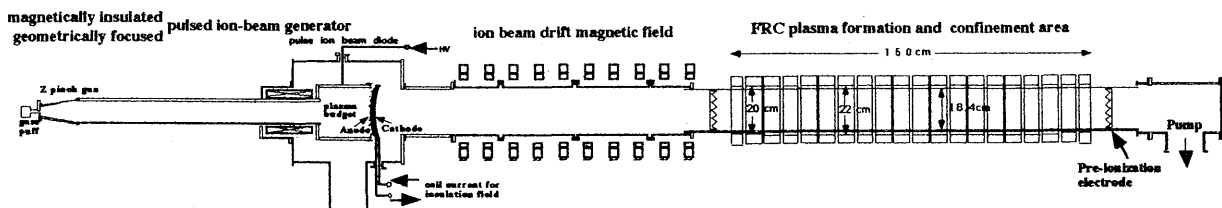


Fig.1. Full schematics of FTHX (FRC Transport Experiment) devise, Osaka University.

experimental devise FTHX was constructed. Preliminary results of plasma formation in the devise are reported here.

A pinch coil is 22cm in diameter and 1.5m in length. Diameter of parts of 12cm long at both coil ends is 20cm to make larger field of a mirror ratio of 1.1 on the axis. Total energy of the main bank is 24kJ at charging voltage of 50kV. The pinch field rises to 5.1kG in 1.6 μ s at 45kV charging. Bias field is 330G. Filling gas of deuterium is 17 mTorr and is ionized by z-discharge current.

A plasma radius r_s is inferred from $\delta\Phi$ and external field at ch.4 (near coil mid-plane) in Fig.2. A value of x_s

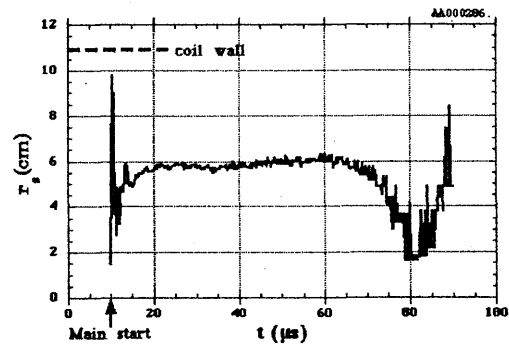


Fig.2. Separatrix radius at a position of ch.4. ($=r_s/r_w$) is almost constant in time and is 0.50~0.55, where r_w is the coil radius. Life time of plasmas is 70~80 μ s. In Fig.3 are showed diamagnetic flux signals ($\delta\Phi$) at ch.4, 9

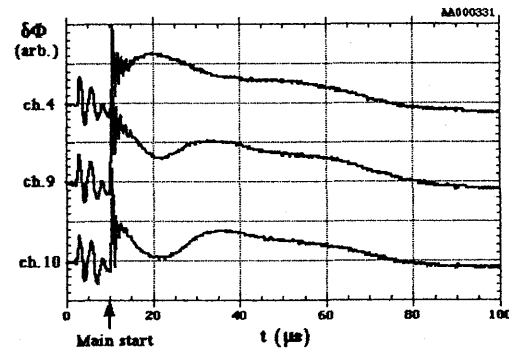


Fig.3. Diamagnetic flux signals at near mirror field. (49cm from the mid-plane), 10 (58cm from the mid-plane). These signals show that plasmas expand up to the position of the mirror coil and continue to push the mirror field during all the plasma life time (no axial shrink). So far, the plasma confinement is, so-called, the mirror field confinement caused by faster decay of external field pressure than plasma pressure.

References

- 1) S. OHI, Fusion Tech. Trans, 27, April, 349, 1995.
- 2) S. HAMADA, Nucl. Fusion, 26, 729, 1986.