§1. MHD Characteristics in an Extremely High-beta Torus Plasma

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1. Introduction

One of important issues of magnetic confinement fusion is to resolve the MHD characteristics of high beta plasma. Non-ideal MHD characteristics, ion kinetic effects, two fluid effect and dissipative effect, have an important role for the plasma stability. A field-reversed configuration (FRC) plasma has high beta value. Its volume averaged beta value is nearly 100%. It has been expected from theoretical works that the mentioned non-ideal MHD characteristics are effective on a FRC stability. Several experimental results, which show non-ideal MHD effects, have also been obtained. For example, in a translated plasma with large normalized Lamor radius and low electron density, interchange instability with toroidal mode number n = 2 has never been grown.

In this work, we have investigated a profile and its time evolution of a toroidal flow in the FRC plasma. Experimentally observed results by using ion Dopper spectroscopy (IDS) system have been compared with the numerical works[1, 2]

2. Experimental Apparatus

The FRC plasma is formed by a negative-biased theta-pinch method in the NUCTE (Nihon University Compact Torus Experiment) –III device.

The IDS system consists of a collector with f = 100 convex-plane lens, a quartz optical fiber tube with 5m of length, a Czerny-Turner grating monochrometer, and a 16 channels photo-multiplier tube (PMT). Dispersed light is magnified by a cylindrical lens with a diameter of 5 mm and detected on the PMT. An impurity line intensity of CV (227.1nm) emitted from the FRC plasma is collected by the collector and transferred to the IDS system through the optical fiber tube. Wavelength resolution and sensitivity between channels are calibrated by Hg line spectrum of 254 nm. The optical resolution per channel is about 0.05 nm in the system. From the obtained shift and broadening of the line spectrum, ion temperature and ion flow velocity can be estimated. To confirm a motion of the FRC plasma and reproducibility of FRC formation, a visible light multi-channel optical detector is arrayed in the x-direction at the same toroidal cross section with the IDS.

3. Experimental Results

Typical plasma parameters of this experiment at equilibrium phase (t = 20 μs) are $\overline{n}_e$: 2×10^{21} m^{-3}, T_i: 190 eV, $r_s(0)$: 0.06 m, Trapped poloidal flux: 0.5mWb, particle confinement time: 80 μs and decay time of poloidal flux: 100 μs. The time evolution of radial profile of toroidal flow is shown in Fig.1. The radial profile of toroidal velocity is almost flat in the very early phase of FRC discharge pulse. However, the acceleration rate of rotation velocity outside of the separatrix is smaller compared to the outside. It indicates the existence of velocity shear in the vicinity of the separtrix. The stability effect of this observed shear on higher toroidal mode number of interchange instability could be a reason why the higher mode of toroidal deformation predicted in the theoretical works has never been observed in the FRC experiments. In Table 1, the results of these toroidal flow measurements are summarized.

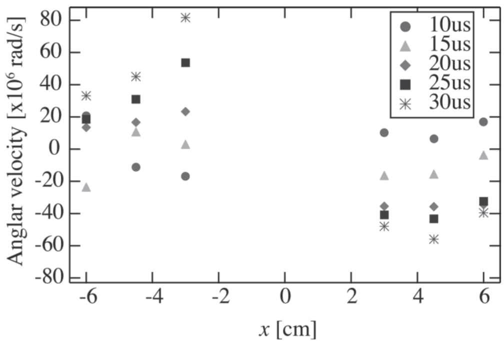

Fig. 1 Time evolution of radial profile of toroidal angular velocity.

Table 1 Summary of experimental results

Position	Rotation direction	Radial profile
Inside of Separatrix	Diamagnetic	Uniform (like rigid body)
Outside of Separatrix	No rotation	-

4. Summary

Investigation of the toroidal flow profile and its time evolution has been started with both methods of experiments and numerical approach. Experimentally observed flow profile is not consistent with past theoretical predictions. Then the experimental results are compared with the newly proposed theory and it is shown that the calculated result agrees with the experimental result. Detailed flow profile measurements and confirmation of the new theoretical model will be continued.

[1] Asai, T. *et al*, in International Toki conference (2007)
[2] Takahashi, T., Yamaura, H., Iizima, H. *et al.*, Plas. Fus. Res. **2** (2007) 008.