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Reconstruction of a toroidal flow profile of a filed-reversed configration
FRCプラズマ内部のトロイダル流速分布の再構成

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Strong toroidal flow is spontaneously generated in a filed-reverse configuration (FRC) plasma. It is continuously accelerated during and after the formation phase. The centrifugal force resulting from toroidal flow causes deformation of toroidal cross section with toroidal number n = 2. The radial profile of this self-generated toroidal flow had been recognized as rigid rotor (RR) i.e. uniform angle velocity profile. the toroidal flow profile in experiment indicates existence of flow shear. In this work, reconstruction of toroidal flow profile by application of modified Abel inversion technique has been performed. The reconstructed profile has been discussed comparing with newly proposed two point equilibrium (2PE) model.

1. Introduction

A field-reversed configuration (FRC) plasma has a strong self-generated toroidal flow. It is continuously spun-up during and after the formation phase(fig1). It causes rotational instability with a toroidal mode number n = 2. This instability terminates the configuration lifetime. Several candidates of physical mechanism of this toroidal spin-up have been proposed, such as selective ion loss[1], end-shorting[2] and flux-decay[3]. As an equilibrium rotation model of FRC, a rigid rotor (RR) model [4] has been recognized which agrees with the experimentally generated FRC plasma. Recently, two point equilibriu (2PE) model [5] has also been presented as more accurate rotation profile mode.

On experiment of NUCTE (Nihon University Compact Torus Experiment)-III, toroidal flow profile is measured by ion Doppler spectroscopy (IDS) revealed that the actual flow profile does not agree with the RR profile. It has a peak at the vicinity of separatrix and falls gradually in the scrape-off region (fig.1).

To increase the accuracy of reconstruction of toroidal flow profile, modified Abel inversion technique has been developed an applied on to the optically observed radial profile of Doppler shift in this work.The reconstructed profile has been compared with rigid rotor (RR) model and two points equilibrium (2PE) models.

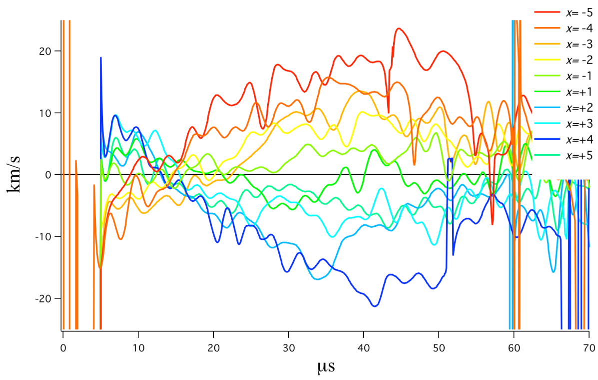

Fig.1. Time evolution of toroidal flow.

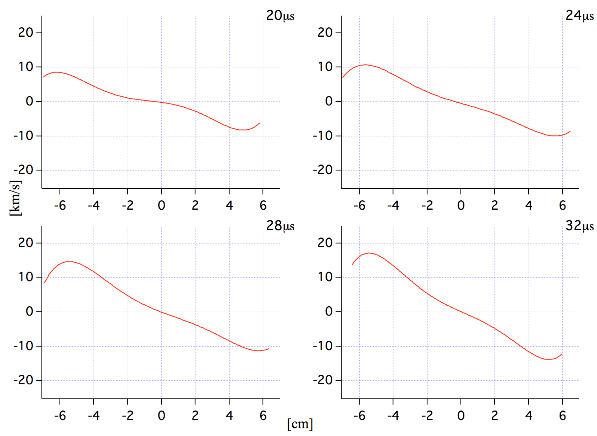

Fig.2. Radial profile of toroidal rotation speed.

2. Experimental device and Diagnostic

The FRC plasma formed by field-reversed theta -pinch (FRTP) method on NUCT-III[6]. This device has a transparent fused quartz discharge tubes 0.256m in diameter and 2.0m in length. A 1.5m long one-turn solenoidal theta-pinch coil is located around discharge tubes. The coil has 5.0mm slit at intervals of 50mm available Spectroscopy measurements. This coil consists of 0.9m long center region with 0.17m I.D. of the coil elements and two 0.25m long end mirror regions with 0.15m I.D. The FRC plasma formed by NUCTE-III is separatrix radius of 0.06m, plasma length: 0.8m, total temperature: 300eV and electron density: $3\times10^{21}m^{3}$. A flux loop and magnetic probes are mounted on the discharge tube surface to measure magnetic flux for excluded flux method. Electron density is measured by a multi chord He-Ne laser interferometer (wave length: 3.39μm). A wobble motion of FRC is observed by an array of 14 optical collimators arranged along the x and y axis at intervals 1cm. It measures emission using a interference band-pass optical filter with the wavelength range of 550 ± 5nm. This range does not have any strong line spectra from impurity and deuterium ions and neutrals. Therefore, the optical system can observe mostly Bremsstrahlung.

The IDS system measure to ion temperature and flow velocity form Doppler broadening and shifting of the line spectrum of impurity carbon (CV:227.2nm). The system consists of a collimator, a quartz optical fiber tube, Czerny-Turner monochrometer, and a 16 channels photo multiplier tube. The wavelength resolution is 0.04nm per channels. As shown in fig.3,

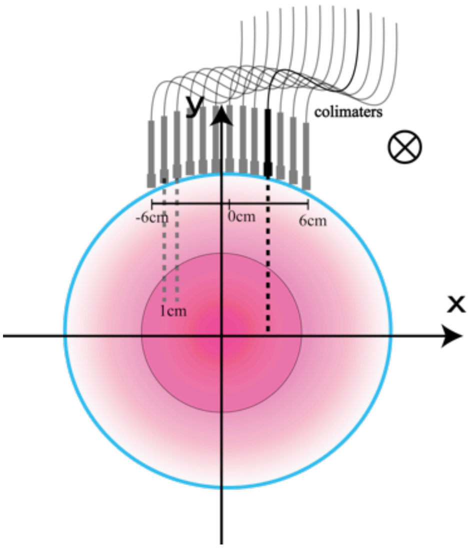

Fig.3. Measurement position of IDS on a toroidal cross section.

the IDS scans ion temperature and flow profile for the range from x = -6 to +6cm at intervals of 1cm.

3. Reconstruction of spectrum distribution

Modified Abel inversion technique has been employed to reconstruct the spectrum distribution. Observed flow profile is based on the line integrated optical measurement. Therefore, the amount of Doppler shift and broadening are evaluated to the reconstructed spectrum.

4. Summary

Observation of toroidal flow profile has been initiated. The measured flow profile will be reconstructed by using modified Abel inversion technique. The profile also compared with the RR and 2PE equilibrium rotation models in the near future.

For further discussion, the profile also compared with the previous experiment of Mach probe measurement [6]. Which is employed to measure the radial velocity profile in the weakly ionized plasma in the scrape-off layer.

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References

[1] D.S.Harned and D.W.Hewett. Nucl.Fusion **24** (1984) 201.
[2] T.Takahashi, H.Yumura, F.P.Iizima, et al. Plas.Fus.Res**2** (2007) 008.
[3] T.Asai, Y.Matuzawa, N.Yamamoto, et al. in 17th international Toki Conference (ITC/ISHW2007) (2007) P1-015.
[4] R.L.Morse and J.P.Freidberg et al. Phys. Fluids **13** (1969) 0531.
[5] L.C.Steinhauer and T.P.Intrator. Phys.plasma **16** (2009) 072501.
[6] Y.Komoriya, Y.Hirayama, Y.Fujikawa, T.Asai, et al. in 19th international Toki Conference (ITC/ISHW2009) (2009) P2-033.