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Simultaneous 3-view measurement of toroidal flow using IDS system in the FAT-CM device

R. Kikuchi[1], K. Araoka[1], K. Kiyota[1], T. Seki[1], D. Kobayashi[1], T. Takahashi[1], T. Asai[1]
[1] College of Science and Technology, Nihon University
e-mail (speaker):csry23009@g.nihon-u.ac.jp

A Field-Reversed Configuration (FRC) plasma is one of the magnetic confinement systems characterized by its remarkably high confinement efficiency. It comprises a compact torus, formed solely by a poloidal magnetic field and a toroidal current. Another salient feature of FRC is its capacity for axial translation , attributable to the absence of interlinked structures within the plasma ring. It has been experimentally observed that the FRC, formed by the field-reversed theta pinch system spins up in the toroidal direction immediately after its formation. This rotation induces the rotational instability with the toroidal mode number $n = 2$, resulting in the deformation of the toroidal cross-section into an elliptical shape. [1]

We have conducted collisional merging experiments on this FRC system. Figure 1 shows a schematic diagram of the FAT-CM (FRC Amplification via Translation-Collisional Merging) device employed in this experiment. FRCs are generated by the formation regions at each end of the device and are translated at a range of Alfvén speed by producing a magnetic pressure difference, achieved by using solenoid-like coils of different diameters. These two FRCs subsequently collide and merge within the confinement section located at the center of the device.[2] Following the impact of the collision, initial FRCs undergo axial compression and subsequently exhibit considerable expansion in both radial and axial directions. The toroidal spin up has been observed on the collisional merged FRC [3].

In this study, our goal is to assess the axial distribution of the toroidal flow of the FRC during and after the collisional merging processes, through the use of simultaneous multi-point measurement of the Doppler shift on the FAT-CM device. [3]

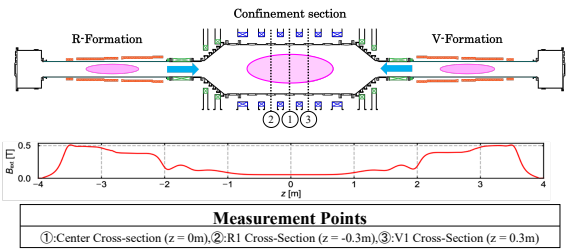

Figure.1 Schematic of the FAT device with the positions of the measurement points. The mid-plane is the origin of z axis, with measurement points placed 0.3m apart on either side.

Figure 2 illustrates the an ion Doppler spectroscopy (IDS) measurement, designed to measure the Doppler shift induced by the toroidal flow, at the central cross-section as viewed from the axial direction, where r denotes the distance from the geometrical axis and r_s represents the separatrix radius.[4] In this measurement, the mid-plane and cross-sections at V1 and R1 within the confinement section are designated as the measurement points. The axial distribution of toroidal flow is derived by concurrently measuring the Doppler shift of the FRC within each cross-section, with impact parameter r varying.

The spectral line of doubly ionized carbon (C III: 229.69 nm), present as an impurity in collisional merging FRC, is measured with a spectrometer. An IDS system, possessing a high time response on the order of microsecond, is employed to accurately measure the spin-up, which occurs on the scale of tens of microseconsds.

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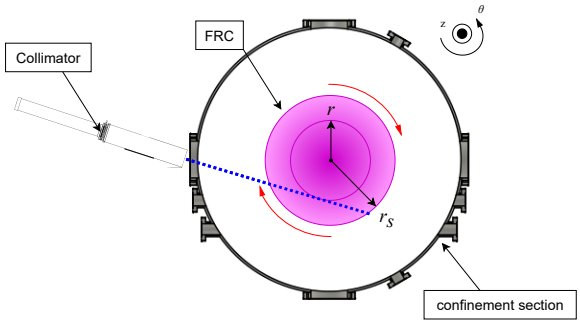

Figure.2 Schematic of measurement of toroidal flow with IDS at cross-section of FAT-CM device