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The intrinsic plasma rotation measurement and spectroscopic model analysis on QUEST

Yushi Maeda[1], Hiroshi Idei[2], Kishore Mishore[1], Takumi Onchi[2], Taichi Shikama[3] et al.

IGSES, Kyushu Univ.[1], RIAM, Kyushu Univ.[2], Kyoto Univ.[3]

1. Introduction

Recently intrinsic plasma rotation in the co-current direction has attracted attention in tokamak fusion plasma with high performance [1]. The plasma scrape-off width has been examined by modeling grad B and curv B drifts against near-sonic flows along the open field lines [2]. In the non-inducting tokamak QUEST plasma, the co-current rotation has been observed in the inboard poloidal field null (IPN) configuration on QUEST [3].

In this research, mechanisms of the intrinsic rotation in the open magnetic field configuration is investigated. The uni- and bi-directional flow patterns are suggested by the model calculation.

2. Experimental apparatus and spectroscopy

A slab plasma is generated near the electron cyclotron resonance (ECR) layer by ECR waves (f_{RF}= 8.2 GHz, P_{rf} ~60 kW, B_{tor}=0.29 T). The poloidal field B_{pol}(<50 G) is applied to generate rotation. Since B_{pol} is positive, the expected current flows in the clockwise direction viewing from the top.

The line spectrum of the impurity ions CIII (464.74 nm) is measured with a spectrometer. The fiber array (25 line of sights) views plasma tangentially at a tangent radius R_{tan} and is connected to the entrance slit [3]. The CCD is located at the exit slit. The profile of toroidal rotation $\langle V_{tor}(R_{tan})\rangle$ is obtained for $|R_{tan}|$ < 1.1m.

3. Model analysis [4]

A local Gaussian spectrum($\Phi(\lambda,r)$) at the radius r is given by the following formulation (1),

$$\Phi(\lambda,r)=\frac{\varepsilon(r)}{\sqrt{2\pi\sigma_\lambda{}^2(r)}}\exp\left(-\frac{\left(\lambda-\lambda_p(r)\right)^2}{2\sigma_\lambda{}^2(r)}\right), \quad (1)$$

here $\sigma_\lambda = V_{th}\lambda_0/c$, $V_{th}=\sqrt{T_i/M_i}$, $\lambda_p=\lambda_0\left(1\pm V_{tor}/c\right)$, c : the speed of light, λ_0 : the center wavelength, and M_i : the ion mass. The local radiation emissivity, ion velocity and ion temperature are denoted by ε, V_{tor} and T_i, respectively. The line of sight wavelength spectrum $I^{cal}(\lambda,R_{tan})$ is obtained by the integration of $\Phi(\lambda,r)$ along the line of sight representing by R_{tan}, described by Eq.(2),

$$I^{cal}(\lambda,R_{tan})=\int_{R\tan}\Phi(\lambda,r)dr \quad . (2)$$

Finally, by Gauss fitting of $I^{cal}(\lambda,R_{tan})$ line of sight profiles of $\langle I^{cal}{}_{peak}(R_{tan})\rangle$, $\langle V_{tor}(R_{tan})\rangle$ and $\langle T_i(R_{tan})\rangle$ are determined. By comparing them with observed ones the local profiles of $\varepsilon(r)$, $V_{tor}(r)$ and $T_i(r)$ are achieved.

4. Comparison of observations with the model

The B_{pol} dependence of $\langle V_{tor}(R_{tan})\rangle$ was examined for $0\leqq B_{pol}\leqq 50$ G. When B_{pol} =0 G, there was no rotation. Figure 1 shows the results (▲: B_{pol}=10 G, ●: B_{pol}=48 G). Model calculations are indicated by dashed-lines. $\langle V_{tor}(R_{tan})\rangle$ < 0 corresponds to the co-current rotation. Here ▲ and ● indicate the counter-current rotation and co-current ones. The latter was characterized by steep gradient at R_{tan} ~ 0.6 m. Figure 2 shows the local profile. △ is explained by parabolic distribution (V_0=0.8 km/s) and ○ is explained by the bi-directional flow pattern ($V_{tor}(r)=V_0\tanh(r-R_0)+V_{offset}$, V_0=4 km/s, V_{offset} = -2 km/s).

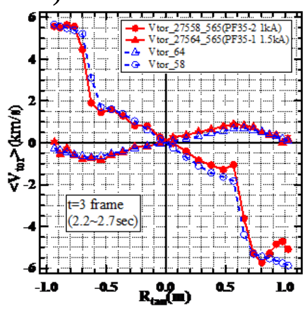

Fig.1 Observation and calculation results

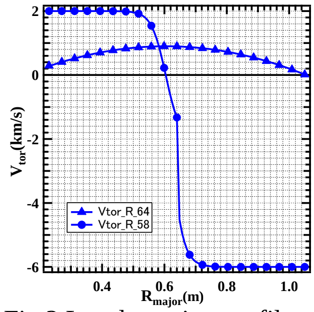

Fig.2 Local rotation profiles at B_{pol}=10 G and 48 G

5. Summary

The intrinsic rotation under the open magnetic field was observed and it was found that the direction of rotation reversed by increasing B_{pol} from counter to co-current direction. Model calculation suggests rotation flow is bi-directional at B_{pol}=48 G.

References

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