6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Characterization of intrinsic plasma rotation in Ohmically heated plasmas of ADITYA-U tokamak using Passive Charge eXchange spectroscopy

G Shukla[1], M. B. Chowdhuri[2], K Shah[3], R Manchanda[2], N Ramaiya[2], K Patel[2], K. A. Jadeja[2], R. L. Tanna[2], K. B. K. Mayya[3], J Ghosh[2] and ADITYA-U Team[2]

[1] ITER-India, Institute for Plasma Research, India, [2] Institute for Plasma Research, India, [3] Pandit Deendayal Energy University, India,

e-mail: Gaurav.shukla_pdf@iterindia.in

The intrinsic rotation velocity of ADITYA-U tokamak plasma and their radial profiles has been measured using Doppler shift Spectroscopy[1]. The toroidal velocity is obtained using the Doppler-shifted passive charge exchange line of C^{5+} at 529 nm, whereas the poloidal velocity is obtained using electron-impact emission of C^{2+} at 464.72 nm [2]. These spectral line emissions are recorded using a space resolved visible spectroscopy diagnostic consisting of a 1-m Multi-track spectrometer coupled with a Charge Coupled Detector (CCD). In typical Ohmic discharges of ADITYA-U, counter-current toroidal rotation velocities are observed in the plasma core with a maximum velocity of ~ 20 km/s. Increasing the plasma density above a threshold value leads to reversal of toroidal rotation direction, suggesting a LOC (linear Ohmic confinement) – to – SOC (saturated Ohmic confinement) transition. Reversal of toroidal rotation velocity is investigated by estimating the radial electric field from the force balance equation. The increased E x B shear due to the large gradient in the estimated radial electric field from rotation measurements seems to be driving the rotation reversal in ADITYA-U.

Toroidal rotation reversal is observed at density values > 3 x 10^{19} m^{-3}. Along with the transition of the confinement regime from LOC to SOC, the dependence of rotation reversal on collisionality is also observed, suggesting the contribution of neutrals. Further, a change in the direction of the residual stress as a function of collisionality is observed, indicating that a source of the residual stress generation could be towards the edge region. In the case of ADITYA-U tokamak, the edge rotation direction is opposite to the core plasma rotation direction. After analyzing the edge density fluctuation by Langmuir probes, it is observed that rotation reversal is not accompanied by a reduction in turbulence in the plasma edge since no change in the ion saturation current is observed. By approximating the non-diffusive component of the momentum transport equation, a sharp gradient from the plasma edge to the mid-radius region and then again from mid-radius to the core region is observed, suggesting that the source of this momentum might be located in the edge region and that edge plasma parameters may drive the intrinsic rotation on ADITYA-U tokamak. The radial electric field estimated from the measured toroidal and poloidal rotation shows a gradient in the radial electric field at the mid radius region. The source of the residual stress could be in the E x B shearing rate arising due to the gradient in the radial electric field.

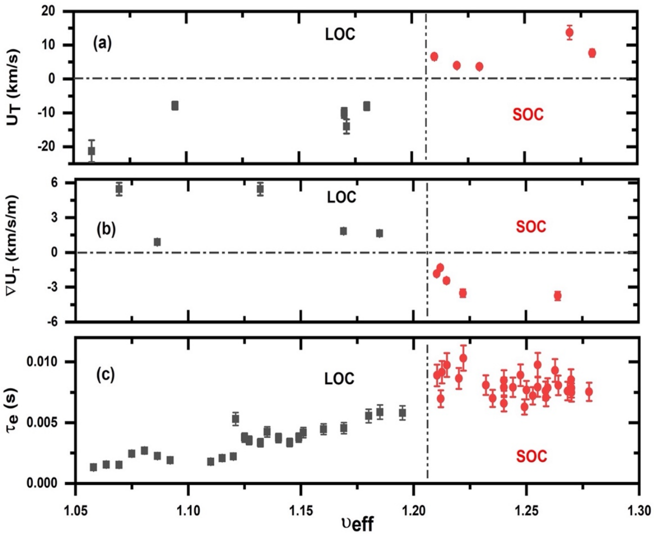

Figure 1. *a) Core toroidal rotation velocities* $(U_T\,(\frac{km}{s}))$, *(b) gradient of toroidal rotation velocity* $(\nabla U_T\,(\frac{km/s}{m}))$ *and (c) global energy confinement time plotted as a function of effective collisionality. The vertical line indicates a change in the direction of rotation velocity from counter-current to co-current direction.*

Furthermore, rotation reversal was also observed during the neon seeding experiments, where the threshold density was reduced to ~ 1.8 x 10^{19} m^{-3}. This could have been due to the improved confinement mode achieved by Ne gas seeding. Efforts have been made to identify the physics mechanism responsible for rotation reversal, and these first results from ADITYA-U tokamak will be presented.

References

[1] Shukla G., *et al* 'Impurity toroidal rotation profile measurement using upgraded high resolution visible spectroscopic diagnostic on ADITYA-U tokamak', Rev of Sci Instr, 92, 063517, 2021.

[2] Shukla G., *et al*, 'Poloidal rotation and edge ion temperature measurements using spectroscopic diagnostic on ADITYA-U tokamak', Atoms, 7(3), 93, 2019.

[3] Shukla G., *et al*, 'Observation of toroidal rotation reversal in ADITYA-U tokamak', Nucl Fus, 59(110), 106049, 2019.