Seminar

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Institute for Plasma Research

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Title:	Plasma Rotation and Impurity Transport Studies in the Aditya-U Tokamak Using Spectroscopic Techniques
Speaker:	Ms. Kajal Shah Pandit Deendayal Energy University, Gandhinagar
Date:	26th October 2023 (Thursday)
Time:	03.30 PM
Venue:	Seminar Hall, IPR

Abstract:

Impact of trace impurities seeding in a tokamak plasma is well documented for their efficient role in controlling the heat loads to plasma facing components through radiative power dissipation. However, their transport mechanisms are not completely understood till date which is a crucial topic in tokamaks realizing the fact that impurity accumulation is highly detrimental for future tokamaks. Hence in this thesis work, Argon impurity transport was studied in the Aditya-U Ohmic discharges using spectroscopic investigations of argon line emissions in the visible and VUV range together with a 1-D impurity transport code. The Aditya-U conventional tokamak has an aspect ratio = 3 (major radius = 0.75 m, minor radius = 0.25 m) capable of producing circular and shaped plasma in limiter and open-divertor configurations respectively. In this work, for the limiter configuration, circular plasmas were analysed.

While visible line emissions of argon impurity occur at Aditya-U plasma edge, VUV line emissions are measured for the core. Modelling these emissions using a 1-D transport code, the profiles of radial diffusivity and convective velocity of argon are obtained. The results indicate that both diffusion and convection contribute to the argon transport. The magnitude of argon diffusion greatly exceeds the neoclassical estimations in both the edge and core regions. The results suggest that argon impurity transport in Aditya-U is purely anomalous in nature and that the turbulence driven by the ion-temperature gradient modes may be the mechanism responsible for the increased transport. Moreover, argon-injection induced loop voltage increase leads to an increase in the Ware pinch, which remains a plausible cause for high convection of argon impurity in the core leading to its accumulation there. Moreover, since plasma rotation plays an important contribution in the overall transport of impurities, intrinsic toroidal rotation profiles have been measured in Aditya-U (pure Ohmic limiter configuration) using passive charge exchange line emission of carbon ions (C^{5+}) at 529 nm. The profiles are investigated in both hydrogen and deuterium discharges. The toroidal rotation in the core has been found to be in the co-current direction for both hydrogen (H) and deuterium (D) discharges and follows the ‘Rice’ scaling. The radial profile measurements revealed that the toroidal rotation has a hollow profile with the rotation reversing to counter current at the mid-radius. At the 4 mid-radius, the H plasma has been observed to be rotating with relatively higher velocities as compared to the deuterium discharges. Thus, a sharp gradient of rotation is observed in core and edge region in H plasma, while the rotation gradients are shallower in D discharges. The neutrals seem to be playing a role in edge rotation while core rotation may be influenced by turbulence. Moreover, higher rotation velocities in H plasma with relatively low-confinement time in comparison to the D plasma, suggests the toroidal rotation is not independent of collisions. These observations demand further extensive investigations to identify the possible mechanisms. To further understand the mechanisms of argon impurity transport and to investigate the intrinsic toroidal rotation scaling in detail, it is crucial to

measure He-like argon line emissions in Aditya-U plasma through soft X-ray Crystal Spectrometer (XCS). Hence, a high resolution tangential soft X-ray crystal spectrometer has been developed from its inception to final installation and initial measurements during this thesis work. The spectrometer is now fully operational on Aditya-U and is envisaged to provide cumulative understanding of various argon impurity transport mechanisms as well more insight into the intrinsic toroidal rotation scaling and isotopic effects in Aditya-U plasma through measurements of He-like Ar line emissions (Ar^{16+}) from the core plasma. Optimization of the Aditya-U discharges with the quantity of argon to be injected, achieving sufficiently high plasma parameters to excite He - like argon line emissions etc. are in progress. Measurements of Ar^{16+} spectral line emissions using the developed XCS remains an immediate future scope of this thesis.