Seminar

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Institute for Plasma Research

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Title: Spectroscopic Investigation of Neutral and Impurity Dynamics in the Edge Region of ADITYA-U Tokamak

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Time: 04.00 PM

Venue: Seminar hall, IPR

Abstract

The tokamak plasma "edge" separates the hot core plasma from the material boundary. Maintaining hot fusion grade core plasma and providing gas fuelling requires understanding this plasma region. Edge plasmas are best diagnosed using spectroscopic methods. This study characterises ADITYA-U tokamak's edge plasma using spectroscopic methods in experiments, simulations, and modelling. ADITYA-U tokamak has a major/minor radius of $0.75\ m/0.25\ m$ and plasma currents of $80-250\ kA$. Its toroidal magnetic field is $\sim 0.75-1.5\ T$. Spectrometers and filter-PMT combinations measure fuel neutral and impurity-ion through passive spectral emissions.

The estimatation of ion/neutral temperatures based on the measured spectral lines shape profiles considering Doppler broadening only leads to large temperature values that cannot be explained reasonably. This error in estimating ion/neutral temperature is corrected by introducing broadening by Zeeman split components as the emissions are subjected to magnetic fields in tokamaks. This has resulted in several intriguing findings, including the existence of a poloidal asymmetry in fuel-neutral temperature derived from Hα spectra. The fuel neutrals reach higher temperatures ($\sim 4\ eV$) on the high-field side than on the low-field side ($\sim 2\ eV$). $H\alpha$-spectra analysis also revealed the presence of warm and hot fuel neutrals originating from various atomic and molecular processes. The radial profile of C^{1+} and O^{4+} ion temperatures using Zeeman-corrected temperatures reveals higher ion temperatures at the locations of MHD islands, which may be related to ion transport within the magnetic islands. Furthermore, the opacity-influenced Li spectral emission in the $Li_2\,TiO_3$ particle injection experiments are used to estimate Li density and radiative power losses. The research also contributes to a better understanding of the interaction of edge plasma with the graphite limiter and the stainless-steel vessel wall. The spectral intensities of $H\alpha, O^{1+}$ $and\ C^{2+}$ emissions from the vessel wall and limiter are measured. Surprisingly, the graphite-limiter and the vessel-wall both contribute nearly equally to carbon recycling. After several plasma discharges, the unexposed vessel-wall acts as a sink and then becomes a source. Furthermore, using the DEGAS2 code, it was discovered that molecular processes cannot be ignored when estimating hydrogen influx using the ionisation per photon (S/XB) factor for $Te < 7\ eV$ in the edge region. The diffusivities of C, O, Ne, Ar, nd Fe impurity species using the impurity transport code STRAHL show a clear dependency of impurity-mass on impurity transport. Experiments in radio-frequency produced nitrogen-contaminated hydrogen plasmas are carried out to establish measurement techniques of vibrational temperatures of N_2 molecules in tokamak far-edge/divertor regions. By recording the different N_2 molecular bands, the vibrational temperatures of N_2 molecules are estimated using the Boltzmann method. Using line-shape simulations, the contribution of the hydrogen Fulcher-band contaminating the $N_2\ 1PS$ bands is identified and successfully removed.