Seminar

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Institute for Plasma Research

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Title: Effect of plasma-driven magnetohydrodynamic activity and pulsed gas-injection on edge plasma turbulence in ADITYA-U tokamak

Speaker: Mr. Kaushlender Singh
Institute for Plasma Research, Gandhinagar

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Abstract

In tokamak plasmas, the understanding, and the controlling capability of turbulence in the plasma edge and scrape-off layer (SOL) regions are crucial for the development of magnetic confinement fusion reactors. The edge and SOL regions of a tokamak plasma are the regions in proximity to the last closed flux surface (LCFS), lying inside and outside of the LCFS respectively. In these regions, the free energy associated with the gradients in mean temperature, density, and potential (∇T_e, ∇n_e, and ∇V_p) induce instabilities like drift wave turbulence, ITG, ETG, blobs, interchange etc. modes leading to fluctuations in these quantities which display turbulent and intermittent characteristics. The turbulence in the edge region significantly impacts the radial transport of particles and heat across the LCFS whereas the SOL turbulence significantly influences the heat and particle fluxes to the material boundaries (limiter/divertor) of tokamak.

In this thesis, the edge/SOL region of limiter discharges of ADITYA-U tokamak is characterized by means of specially designed Langmuir (single and triple) probes with fixed and reciprocating drives. By systematic and exhaustive measurements in the edge/SOL region of typical discharges of ADITYA-U tokamak, a turbulent nature of the density and potential fluctuations is observed in edge region whereas significant intermittent behavior is detected in the SOL region. To investigate the role of neutral atoms on turbulence and intermittency in the edge/SOL region of tokamaks through various mechanisms like charge exchange and radial electric field modifications, fuel gas neutrals are injected in form of short pulses in the SOL/edge region of ADITYA-U. It has been observed that the gas-injection leads to flattening of radial profiles of mean density and potential in the edge region, resulting in reduction in their fluctuation amplitudes. However, the degree of intermittency increases in the edge region in presence of gas-injection. Interestingly, although the intermittency increases in the edge region following gas-injection, the overall confinement increases, indicating that the transport in ADITYA-U is mainly governed by drift-wave turbulence in the edge, which decreases with gas-injection. Hence, through controlled gas-injection, the edge/SOL turbulence and intermittency can be controlled to optimize the behavior of complete plasma in terms of transport and confinement.

The external magnetic perturbations are also known to modify the edge turbulence. In this thesis, an effect of magnetic perturbation generated by plasma-driven (internal) magnetohydrodynamic (MHD) activity on edge turbulence is explored and impact of internal MHD activity on edge turbulence is experimentally demonstrated. It has been observed that the MHD modes, mainly the m/n = 2/1, beyond an amplitude threshold value of $\tilde{B}_\theta/B_\theta \sim 0.3 - 0.4$ %, excite coherent oscillations in the density and potential having the same frequency as the

MHD mode. Interestingly, the mode investigation of the excited mode reveals that the coherent mode in edge potential fluctuation has a mode number of m / n = 2 / 1 whereas the edge density fluctuation has a mode number of m / n = 1 / 1. The coupling of even harmonics of potential to the odd harmonics of pressure is due to 1/R dependence of the toroidal magnetic field. Furthermore, the MHD induced coherent modes result in a reduction in edge turbulence and associated transport. This is contrary to the expectation of a detrimental effect on confinement due to enhanced MHD modes and indicates towards self-healing of discharges. The complete thesis work including the above will be presented in the synopsis talk.