Seminar

Institute for Plasma Research

Title : Study of Runaway Electrons and their Interaction with Magnetic and Electric fluctuations in ADITYA and ADITYA-U tokamak

Speaker: Ms. Harshita Raj
Institute for Plasma Research, Gandhinagar

Date : 8th March 2019 (Friday)

Time : 11:30 AM

Venue : Committee Room 4, (New Building), IPR

Abstract :

Prevention and mitigation of runaway electrons, electrons that are collisionally decoupled from the bulk plasma and accelerate freely to very high energies (~ several tens of MeVs), from tokamak plasma is a major thrust area of ongoing thermonuclear fusion research as they pose a severe threat to the peripheral plasma facing components. Scaling the energy of the RE beam produced during plasma disruption in presently operating big machines like JET, portrays a very alarming projection for ITER. Due to their destructive nature, experimentation with REs are not very much desirable in bigger tokamaks. And hence the mid-sized tokamaks like ADITYA and ADITYA-U, where the maximum attainable RE energies are not very high (< 5 MeV), are most suitable for carrying out the RE experiments. The REs are known since the birth of tokamak and the generation mechanism of REs is understood to an extent, however, the loss or mitigation mechanisms of these REs are very poorly understood. There are several mechanisms for generation as well as for loss of REs from the plasma and the RE content in any plasma depends on the rates of generation and loss.

In this thesis work, the generation and loss mechanisms of REs in ADITYA and ADITYA-U tokamak (minor radius, a=25 cm and major radius, R=75 cm) have been studied in detail. The studied discharges have: plasma current ~80–120 kA, chord-averaged electron density ~ (1–4) × 10^{19} m^{-3}, chord-averaged electron temperature ~ 200–500 eV and toroidal magnetic field ~ 0.75 - 1.2 T. It has been observed that in majority of the cases the conventional sources of generation and loss do not explain the observed RE dynamics in these machines. It has been established that sawteeth instability can generate REs during plasma current flat top where the conventional source is incapable of generating them. It has been shown that overlapping of two MHD islands (m/n=2/1 & 3/1) significantly enhances the radial RE loss, whereas the RE loss is reduced when good magnetic surfaces exist between the islands. Analyzing a large number of discharges, it has been observed that the presence of a large magnetic islands (> 5 – 10 % of minor radius) tends to decrease the RE loss. Furthermore, these large islands, corresponding to m/n=2/1 MHD modes, also show multiple harmonics, which are found to be dependent on rotation frequency and amplitude of the 2/1 mode. In order to characterize further the effect of these MHD modes on RE loss, the 2/1 MHD mode amplitude and frequency have been altered in a controlled fashion by periodic gas puffing during the course of a single discharge. These periodic gas-puffs also resulted in reduction of turbulent electrostatic fluctuations (TEF) in edge/SOL plasma region. A comparative study of magnetic and electrostatic fluctuation in presence and absence of periodic gas puffs for several discharges in ADITYA-U indicates that the TEF in the edge of ADITYA-U are related to RE loss mechanism and can be thought of as a mitigating mechanism for the REs. Apart from the RE experiments, this thesis work also includes confinement analysis of ADITYA tokamak plasmas and fueling of tokamak plasma by the gas-puffs applied for density maintenance and enhancement.