Seminar

Institute for Plasma Research

Title: Density evolution studies during plasma formation and current flat-top phases in ADITYA-U tokamak using Microwave Interferometer

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Abstract

The process of ionizing neutral gas to initiate a plasma discharge along with the evolution of plasma density in this phase is a complex and critical stage of plasma initiation in any tokamak. It faces several key physics and engineering challenges. The breakdown of gases in tokamaks are studied extensively, however, the density evolution during and immediately after the breakdown is not fully understood as plasma driven ionization depends on the prevalent plasma properties in that time period. Furthermore, the density and its profile gets modified during the plasma current flat-top due to fueling via different methods such as gas-injection through the periphery of the plasma. The gas-injection also modifies the other plasma parameters such as confinement time etc. which still needs better understanding.

In this thesis work, two different types of microwave interferometer systems have been developed to measure density and its profile in ADITYA-U tokamak. Using these systems the density evolution during the plasma formation and in the current flat-top phase has been studied. One system utilizes microwave frequency of 140 GHz in phase lock loop arrangement while the other system utilizes a 100 GHz microwave source in free running mode to measure the density and its profile in ADITYA-U tokamak.

To understand the density build-up during the plasma formation and burn-through phase of Ohmic discharges of Aditya-U tokamak, density in this phase has been measured using 140 GHz real-time heterodyne microwave interferometer system. Statistically analyzing several tens of discharges, it has been observed that the central chord-averaged density and the corresponding ionization fraction (~ 3 – 5 %) during the avalanche phase remains independent of the externally applied toroidal electric field and the pre-fill pressure. Further investigation revealed that the build-up of density in the initial burn-through phase, is highly influenced by the turbulent magnetic fields. The turbulent magnetic fields leads to turbulent E x B drifts, which seems to facilitate the ionization.

The effect of fueling through gas injection from the plasma periphery on the evolution of total density and its radial profile is studied by using the developed Interferometer systems measuring density through three chords passing through different radial locations in the plasma poloidal cross-section. The radial profiles of density are obtained by inverting the measured chord averaged density. The total density variation and modification in its radial profile after gas injection is studied. It has been observed that the density profile broadens after the gas injection and the total density increases. The profile broadening depends on the amount of gas injection. A particle confinement time of ~ 15 ms is obtained from density decay time after the gas-puff pulse for the analyzed set of discharges. This global confinement time estimation gives an average particle diffusivity ~ 1 - 2 m^2/sec in the analyzed set of discharges.

The details of development of two types of microwave interferometers in heterodyne configuration along with studies of density evolution in the plasma formation phase and density profile variations due to gas injection will be discussed in this thesis synopsis presentation.