Seminar

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Institute for Plasma Research

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Title:	Understanding of power coupling in a fusion grade ICP device using COMSOL Multiphysics Simulations
Speaker:	Dr. Ram Swaroop Institute for Plasma Research, Gandhinagar
Date:	30th January 2025 (Thursday)
Time:	10:00 AM
Venue:	Seminar Hall, IPR

Abstract

Fusion reactors are pivotal for addressing future energy challenges without creating greenhouse gases. Neutral Beam Injector (NBI) is one of the most useful auxilliary plasma heating system to heat the fusion plasma. ITER is an experimental fusion reactor uses negative hydrogen isotope based NBI (NNBI) systems for plasma heating, current drive and He ash diagnostics. ITER's one negative ion source consists of eight inductively coupled plasma drivers, powered by 800kW, 1MHz RF power supply. To understand the RF power coupling in one RF driver COMSOL Multiphysics simulations are carried out. The dimensions and configuration of ROBIN ion source RF driver is considered to benchmark the simulation. ROBIN is a single RF driver based ion source whose overall size is 1/8th of ITER NNBI ion source. ROBIN is operational and experimental data are available for the purpose of benchmarking of the simulation.

Simulation is carried out by changing operational pressure conditions, RF coil antenna positions on the cylindrical driver wall in presence of RF Faraday shield and also in absence of it. From simulation outcomes it is observed that by adjusting the RF coil position, the electron temperature varies in the ranges from 14.7 eV to 17.7 eV. On the other hand, when the pressure increased from 0.3 to 1.0 Pa the plasma density is increased from 1.48E17 to 1.03E18 $1/m^3$, while electron temperature is decreased from 17.8 eV to 8.7 eV respectively. Furthermore, when a Faraday shield (FS) is inserted inside the RF driver, plasma density is improved to 2.03E17 (1/m3) at 0.3 Pa with a electron temperature around 18.3 eV. When a set of external permanent magnets are inserted in cusp geometry at the backside of the FS, plasma confinement further enhanced resulting increase in plasma density to 2.08E17 (1/m3) and a significant effect on the plasma potential is also observed. It is realized that the gas temperature also influences the plasma dynamics.

The simulation study lays a robust foundation for advancing hydrogen isotope-based ICP plasma understanding which may help to optimize next-generation ICP-based ion source for fusion grade NNBI.