# Seminar

# Institute for Plasma Research

**Title :** Studies of cavity modes on plasma and its influence on ion beam in a microwave ion source

**Speaker:** Mr. Chinmoy Mallick
Institute for Plasma Research, Gandhinagar

**Date :** 1st March 2022 (Tuesday)

**Time :** 10.30 AM

**Venue :** Online - Join the talk:
https://meet.google.com/rgy-qpuf-zkz


**Abstract :**

Microwave discharge ion sources (MDIS) are very popular among the accelerator community to meet the growing needs of high current, low emittance stable ion beam even for the material processing industries and nuclear applications. The production of a high current ion beam depends on the plasma density as well as the confinement time of the plasma particles. The high-density plasma is generated in an ion source cavity by the appropriate coupling of the microwave (MW) electric field energy to the gaseous particles through the ECR as well as off-resonance heating methods. Generally, the wavelength of the MW electric field is within the comparable range of the ion source cavity dimension. Therefore, the electric field after entering into the ion source cavity becomes a guided wave and is distributed throughout the cavity following the pattern of a particular type of cavity mode(s). The enhancement of the plasma density and the improvement of its confinement are also associated with the plasma perturbations and its non-uniformity across the cavity based on mode(s) structure. These phenomena influence the extracted ion beam in terms of beam emittance, beam halo formation, and beam oscillations, etc. A good quality ion beam (high current and low emittance) is achievable by adopting the proper launching scheme and correspondingly optimizing the MW coupling into the plasma. One of the main influential parameters that can control the efficiency of the MW power coupling to the plasma and hence the beam quality is the cavity resonant modes that are excited by a properly designed ion source geometry and magnetic field configuration. Therefore, the motivation of the current thesis is to develop a microwave ion source to study the cavity mode(s) in a MDIS plasma, and its influence on the qualities of the extracted ion beam.

In the current study, three cavity modes are observed which have influenced the plasma parameters significantly. In the experiment, different power coupling phenomena are identified, Electron cyclotron resonance (ECR), electrostatic wave heating due to parametric decay (PD), and phase modulation (PM) to explain the over-dense plasma and high energy electron generation respectively inside the ion source cavity. The cavity modes generate electrostatic waves through PD that cause to raise the density far beyond the cut-off corresponding to the launched 2.45 GHz MW frequency. Correspondingly, the temperature of the plasma particles is increased due to the heating through the electrostatic and the phase-modulated wave. Linear and nonlinear interactions of the cavity modes generate instabilities and waves which are transmitted into the ion beam that impacts the beam emittance and its stability significantly. Some of the above-mentioned experimental findings are cross-checked with Spatio-temporal MW-plasma simulation considering the boundary conditions, similar to the experimental configuration and the operating environment. It is concluded that MW power coupling is sensitive to the cavity geometry and magnetic field configuration due to presence of cavity modes. Cavity geometry and magnetic field play a decisive role in designing an ion source for optimal beam performance. The multiple cavity modes based heating is an efficient power coupling mechanism, which can be considered as an alternative to the power coupling based on the frequency tuning method.