Abstract

Experimental study of low frequency electrostatic fluctuations in a low β toroidal plasma is undertaken in this thesis work. The experiment is conducted in toroidal device BETA (acronym for Basic Experiments in Toroidal Assembly). During the experiment the effect of gravity is simulated by curvature of toroidal magnetic field. Two sets of experiment are carried out during the experiment. In the first set of experiment, ECR formed toroidal plasma is studied, whereas in the second set of experiment, filament produced plasma is studied.

The set of experiments needed to study various properties of ECR formed toroidal plasma is conducted in BETA machine. The device consists of a torus, constructed out of four quadrants of stainless steel, with a major radius of 45 cm and minor radius of 15 cm, placed in a pure toroidal magnetic field produced by 16 toroidal field coils surrounding the torus. The toroidal field coils are of picture frame shape with square aperture. A maximum toroidal magnetic field of 0.1 T can be produced upto 1.2 seconds. Using rotary and diffusion pump, the vessel is evacuated to a base pressure of 8 x 10^{-4} Pa. Hydrogen and argon plasma is formed at a working pressure of 1.3 x 10^{-2} Pa. A limiter of diameter 18cm is used to short-circuit the electric field established due to curvature and ∇B drift to provide equilibrium to the plasma. The limiter is placed at a toroidal location of 180^o away from the plasma source. Both the limiter and the vessel is grounded. Plasma is produced using two different sources. In the first part of the experiment, electrodeless production of plasma is undertaken. A 2.45 GHz., 800W, magnetron based microwave source is used to form ECR plasma, whereas in the second part of the experiment, a thoriated tungsten filament of length 14 cm and diameter 2 mm, vertically

positioned at the minor axis, is used as a hot cathode discharge source. A discharge voltage of 110 V is applied between the filament and the vacuum vessel.

Electrostatic coherent low frequency fluctuations that are present in the ECR formed toroidal plasma is studied. μ*-wave produced plasma in a toroidal device behaves quite differently as compared to the plasma produced by filament method. This difference could be clearly observed in our experiments where electrode-less source (ECR method) is used to form the plasma.*

We report here production of hydrogen plasma using 2.45 GHz microwave source in a toroidal device BETA. Equilibrium density, floating potential and plasma temperature in the poloidal cross section have been measured. Contours of equal density and floating potential exhibit slab nature in the vertical direction of the poloidal cross-section. Plasma is formed with a peak density of 3×10^{10} cm^{-3}*. The electron temperature is about 4-7 eV. Our measurements reveal that X-mode wave gets mode converted to electrostatic modes near upper hybrid resonance (UHR), which propagates close to electron cyclotron resonance (ECR) region where entire energy of the waves are deposited. Thus we observe plasma profiles broadened towards the weaker magnetic field region upto the UHR region, with an inner boundary near ECR region. This is further supported by numerical calculation. Fluctuating component of the density and floating potential is also measured. Low frequency (LF) electrostatic instabilities are observed to be radially localised. Presence of both, flute and drift modes is reported. Our measurements reveal that the excitation of LF fluctuations depends strongly on the sign of product* $\nabla n . \nabla B$ *where* ∇n *and* ∇B *are the radial density and magnetic field gradients respectively. LF coherent fluctuating modes are observed in the region where* $\nabla n . \nabla B > 0$ *and turbulent spectrum is observed where the condition* $\nabla n . \nabla B < 0$ *is satisfied. Our measurements reveal that collisional drift modes could be excited when* $\eta_e < 0$ *(where* $\eta_e = \nabla \ln(T_e) / \nabla \ln(n_e)$*), whereas R-T modes could be excited when* $\eta_e > 0$ *and density gradient is antiparallel to 'g'.*

In the second set of the experiments, filament produced plasma is studied. Argon plasma is formed. A detail measurements of density and floating potential over the poloidal cross section, at a fixed toroidal location is conducted at different toroidal magnetic field. The same is studied in the presence of a small vertical magnetic field. The measurements related to the studies of low frequency (LF) electrostatic fluctuations in a toroidal device BETA in the presence of a weak vertical magnetic field is presented. The density and floating potential isocontours exhibit slab nature of the plasma, away from the filament region, in the vertical direction and closes elliptically. Suppression of the fluctuation level in the presence of the vertical field is observed. By suppression here, we mean reduction in the total power in the frequency band upto 25 kHz. The vanishing of the divergence in BETA device is established, based on our experimental results, which establishes the existence of slab equilibrium in our machine.