ECR plasma characteristics in a tight aspect ratio device with varying toroidal magnetic field

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Abstract

In a low aspect ratio device "STARMA", the characteristics of the electron cyclotron resonance (ECR) produced plasma is reported. A magnetron source with a frequency of 2.45GHz is used to produce the plasma employing ECR technique and is launched in O-mode. To form ECR plasma at fundamental mode for the 2.45GHz source, a magnetic field of 875G is generated. As the toroidal magnetic field is produced by a pulsed source which varies temporarily, it generates a time varying toroidal magnetic field at a given radial location. Thus the ECR location, in this mechanism, keeps changing radially with time and it is expected that the ECR produced plasma should also evolve temporarily at various radial locations. With this motivation in mind the ECR plasma in STARMA is studied with helium gas at fill pressure ranging from 10^{-4} mbar to 10^{-3} mbar. The vessel is pumped up to a base pressure of 10^{-7} mbar with the help of 500 liter turbo-molecular pump (TMP).

The diagnostics employed in these studies mainly comprises of Langmuir probes (LP) and visible fast camera. The single LP is used to measure I-V characteristics of the plasma at a fixed radial location, using which electron density and temperature of the plasma is estimated. Triple Langmuir probe is also used to measure the temporal evolution of electron density and temperature at a given radial location. The probes are moved radially to measure the radial profile of the plasma parameter from shot to shot.

The experimental results indicate that initially, when toroidal magnetic field shoots to maximum, the plasma is formed radially with a peak density of $\sim 5.8\times10^{16}$ m^{-3} located towards the machine center ($r \sim R_o$). As time progresses the peak density of the plasma moves radially inward ($r < R_o$) with peak density reaching up to $\sim 8.3\times10^{16}$ m^{-3}. It is observed that the density scale length ($L_n = \frac{n_e}{\Delta n_e}$) increases when the ECR layer moves to the inboard side and explains the increase in the density as toroidal magnetic field decreases with time. The plasma temperature nearly remains constant radially with a value ~10eV.

Our analysis confirms that the plasma density do not peak at the ECR location but shows a radial spread defined by the upper hybrid resonance (UHR) and the ECR layers. It further suggests O–mode to X–mode conversion when it encounters the inner vessel wall or from left hand cut-off. It is expected that at UHR, the converted X-mode gets further converted to EBW.