Transverse Drift Velocity of Argon Plasma in a Curved Magnetic Field

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Abstract: ***Transport of plasma structures across magnetic field lines in scrape-off-layer (SOL) of Tokamak like machines, have convective like features. This cross-field transport has fascinated researchers and is an important field of research. The typical radial velocities are ~ 10^3m/s. In this communication, transverse drift velocity of plasma structures from a washer stacked plasma gun is reported.***

Keywords: Scrape-off-layer (SOL), Tokamak, Cross-field transport, Drift velocity, Plasma Gun.

1. Introduction

Fast radial plasma transport in the scrape-off-layer (SOL) has not diffusive but convective like features [1]. One of the plausible mechanisms of this fast convective SOL plasma transport can be associated with plasma blobs. Experimental evidence most clearly show the intermittent character of plasma turbulence in a TOKAMAK scrape-off-layer (SOL) and the importance of coherent high plasma density structures, "Blobs", in convective cross-field plasma transport [2]. Typical radial velocities are of the order 10^3 ms^{-1} [3-4].

In our laboratory a washer stacked plasma gun is used to produce a blob of plasma which injected with high speed ~ 10^3 m/s into the curved vacuum chamber [5]. Using velocity probe [6], the speed of pulsed plasma is measured for different working conditions without disturbing the plasma. The pulsed plasma interacts with two parallel Langmuir probes placed at a known distance inside the chamber and the speed of plasma blob can be measured using time of flight technique [6,7]. The speed of argon plasma in the absence of external magnetic field was reported earlier in detail [8]. Transverse drift velocity of nitrogen dominated plasma shows a decaying trend as one move away from gun mouth [9]. Transverse drift velocity argon plasma shows similar trend.

2. Experimental Set Up

The present work has been carried out in CPS device [5].The vacuum chamber is evacuated by means of a diffusion pump coupled with a rotary pump and a low pressure (~0.06 mb) is maintained throughout the experiment. The gas feed network is meant for supplying working gas into the gun. Here, argon gas is used as the working gas. Pulsed plasma is produced by washer plasma gun and injected into the chamber. The gun is energized by a multistage pulse forming network (PFN), consists of capacitors (~5μF) and inductors (~1.5 μH) [10]. To match the gun impedance with that of PFN, a series resistance is also used. Two parallel probes of 0.02 m separation was mounted inside the chamber by -Wilson fed through system. The radial distance of probes from plasma gun, which fitted on outer side radial port extension, can be varied [8].

A pair of insulated copper wire of thickness 2.94×10^{-3} m wound over the chamber, each having 25 turns. A pulsed current is generated by a 100μF, 10 kV capacitor bank and a pulsed toroidal magnetic field is generated inside the vacuum chamber. The plasma is injected simultaneously by triggering a washer stacked plasma gun. The magnetic field generated inside the chamber is measured by using a magnetic probe having 720 turns. The probe is calibrated using Helmholtz Coils. The magnetic field strength ~ 0..4 T at the middle of the chamber.

The PFN is discharged after triggering and pulsed plasma moves with high speed and interacts with the two probes. The signals are recorded by a four channel storage oscilloscope and are transferred to a Computer (PC). Signal from probe-2 is intentionally connected with both Ch. 3 and 4 for better accuracy in measurement. Time delay in receiving the plasma by two probes has been obtained from the signals on Cathode Ray Oscilloscope (CRO) as shown in figure- 2.

The speed of fast moving plasma along the radial distance of chamber has been measured by time of flight technique using the formula [6,7],

$$u = \frac{\Delta d}{\Delta t} \qquad (1)$$

Where, Δt is the time elapsed to cover distance Δd between two probes.

The 1st velocity probe (LP) signals attained a high peak and after very short time interval (t=242 μs) 2nd probe received the plasma signal. The distance between two probes is 0.8 cm. As the probes are fabricated in our lab high precession is difficult to maintain. So, the speed of plasma is 3306 m/s (using formula given in equation 1). The speed is assigned to the distance 4 cm at base pressure 0.06 mb and discharging potential 0.5 kV. Plot of CRO Signal from velocity probe system is shown in figure-2.

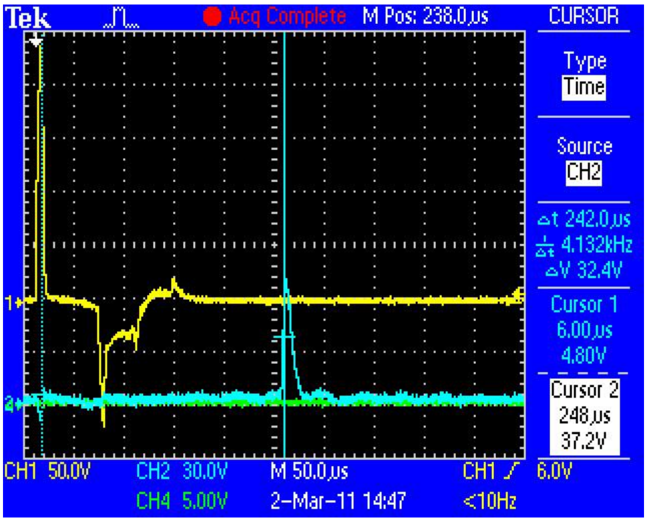

Figure 1: CRO Signal of velocity probe system (Ch-1 and Ch- 2 shows signals received by probe-1 and 2 respectively)

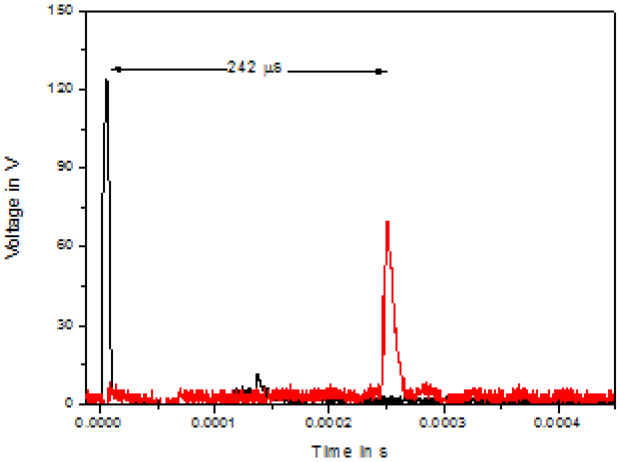

Figure 2: Plot of CRO Signal from velocity probe system

3. Results and Discussion

The transverse drift velocity of plasma from washer plasma gun is measured using time of flight technique as described in previous section. The working gas is argon. The spatial variation of transverse drift velocity of argon plasma is shown in figure-3. The data is compared with that of transverse drift velocity of nitrogen dominated plasma. It is observed that as the plasma moves away from plasma gun its velocity decreases. The decrease in velocity is due to decrease in energy content in the plasma as time passes by. The plasma structure interacts with the neutral particles in plasma boundary and thus losses energy.

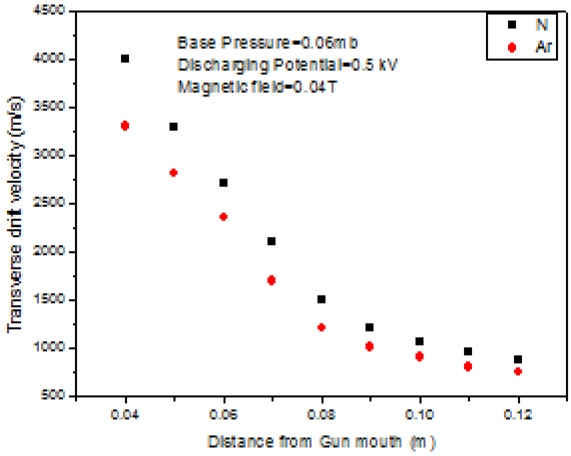

Figure 3: Spatial drift velocity of argon plasma in a curved magnetic field (~0.04T) at discharging potential 0.5 kV and base pressure 0.06 mb.

The trend is similar both for nitrogen dominated plasma and argon plasma. However, the velocity for argon plasma is less in comparison to nitrogen plasma. This is because argon is heavier than nitrogen. Spectroscopy signature of plasma shows presence of argon lines [11].

4. Conclusion

The transverse drift velocity of plasma is measured at different distances from plasma gun and found to be ~10^3m/s. It has been observed that velocity decreases since it losses energy, as the probes move away from gun mouth. The velocity of argon plasma structure, with B = 0.04 T varies from 3.3×10^3 m/s to 0.75×10^3 m/s when the radial distance from the plasma gun increases. The plasma gun is placed at the high field side of the chamber, where the magnetic field is higher than its value at the center, more variation in velocity is observed. Further away from the gun, where the magnetic field decreases as 1 / R, the velocity does not change much. These finding would be very helpful for researchers working in the field of magnetic confinement.

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