Introduction

We present a comparison of ion velocity measurements obtained by RFEA and LIF, of an ion beam due to current free double layers in an expanding argon helicon plasma. The RFEA in plasma is surrounded by a sheath so the velocities measured by the RFEA are the velocities of the ions after they have been accelerated by the sheath and any potential drops inside the probe. Earlier studies have shown that the main distribution measured with an RFEA is much broader than that of LIF [1].

We have also investigated if swapping the repeller and discriminator grid in the probe would change the ion focusing effects [2, 3] in the RFEA, and if keeping the front grid and aperture floating instead of grounded will improve the measurements.

The experiments are done at the West Virginia University's HELIX-LEIA-vacuum chamber. The LIF system is using a dye laser tuned to 611.622 nm to pump the Ar-I 42G1/2 metastable state to the 42P5/2, which then decays to the 42D3/2 state by emitting 464.06 nm photons.

Ion focusing / change of grid

Comparison of different grid configurations. (Black) repeller first and floating front grid. (Green) repeller first and grounded front grid. (Blue) Discriminator first and floating front grid. (Purple) Discriminator first and grounded front grid. We see that when the discriminator is first there is a changing ion focusing effect in the probe that decreases as the discriminator voltages approaches 0 V, leading to a small decrease in the ion saturation current as less of the background ion distribution enter the probe. This also leads to a thinner distribution with more energy resolution.

Letting the front grid and aperture float does not seem to improve the measurement. Instead the grid drops at a lower potential than the plasma floating potential (See figure c and g), creating a larger sheath and accelerating more ions toward the probe.

Beam width / radial scan

Comparison of radial scan at 2 ± 80 cm with Langmuir probe and RFEA. (a) Plasma density derived from the ion saturation current of the Langmuir probe. (b) Plasma potential measured by using the derivative of the Langmuir current. The colored symbols are plasma potentials derived from the peak in the distribution from the RFEA measurements. (c) Floating potential of the Langmuir probe. (d) Electron temperature from the Langmuir probe. (e) Ion saturation current in the RFEA at different grid configurations. (f) Measured beam current from the RFEA. (g) Potential of the front grid when using floating front grid. (Notice that the grid is not floating at the plasma floating potential). For the RFEA measurement with a floating front grid we see that the ion saturation current keeps increasing with r while for the grounded front the current has a maximum at 20 cm. This might be due to the deep drop in potential for the floating front (g) from around 20 cm leading to a larger sheath and therefore higher saturation current.

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Schematics of the grids in the RFEA for (b) the repeller in front of the discriminator and (c) the discriminator in front of the repeller. Both configurations can have the front grid either floating or grounded. We use 3 grids and a collector in the RFEA. The front grid is either floating or grounded, the repeller grid (R) biased to -100 V to repel electrons; the discriminator (D) discriminates ions based on velocity, and a collector (C) biased to -9 V to collect the ion current. Sometimes a RFEA uses an extra grid, a suppressor (S) to suppress secondary electrons from the collector. We could not see much difference with and without suppressor in these measurements. So we eliminated that grid to be able to control the front grid instead.

Results and discussion

Comparison of RFEA measurement in different directions. At 0° the peak in the background distribution is at 150 V while at 90° (perpendicular to the beam) the peak is at 14.73 V. This difference corresponds to a flow of 1 k/cm.

References