Double Layers In Expanding Helicon Plasmas

Charles and Boswell [2003] used a Retarding Field Analyzer (RFEA) to measure plasma densities, plasma potentials, and ion energies in an expanding plasma created in the Chi-Kung helicon source. They found that a double layer (DL) occurs for pressures less than 1 mTorr in argon and that as pressure was decreased, the potential drop across the DL increased. Using Laser Induced Fluorescence (LIF) and at similar plasma conditions, Sun et al., [2003] observed spontaneous DL formation in their experiment. As shown in the figure below, the pre-sheath and sheath regions, background ion population, and accelerated ion beam are easily identifiable in the LIF measurements.

However, the thickness of the DL (in terms of Debye lengths) seen in the LIF measurements is much larger than the DL thickness reported from RFEA measurements. To better understand the differences between RFEA and LIF measurements of the same ion populations, we have been engaged in a series of DL experiments in which RFEA, LIF, and rf-compensated Langmuir probe measurements are performed (see Harvey et al. poster adjacent to this poster).

Effects of RF Frequency on Stability of Double Layer

- RF frequency has significant effect on stability of low-pressure plasmas
- Double layer appears more stable at higher RF frequencies
- At low gas pressure (less than 3 mTorr as measured at the far end of the helicon source) and mid-range RF powers, a strong axial gradient in electron temperatures and plasma potential appears. At slightly higher RF powers, the axial structure vanishes.
- The next step is a detailed comparison of RFEA and Langmuir probe measured plasma potentials at the same physical location. In these initial data, the two measurements differ significantly. The Langmuir probe yields plasma potentials on the order of 5 V, while the RFEA indicates that the plasma potential is on the order of 25 V

Experimental Geometry

<table>
<thead>
<tr>
<th>Pressure at End of Source (mTorr)</th>
<th>Axial Position (cm)</th>
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<tbody>
<tr>
<td>0.1 mTorr</td>
<td>180</td>
</tr>
<tr>
<td>1.3 mTorr</td>
<td>200</td>
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</tbody>
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Summary:
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