Two Dimensional LIF Measurements and Potential Structure of Ion Beam Formation in an Argon Helicon Plasma

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We report 2-dimensional, spatially resolved observations of ion beam formation in an expanding helicon plasma. Previous studies found that a current free double layer (CFDL) spontaneously arises at low pressure, below 1 mT. We use Laser Induced Fluorescence (LIF), a non-perturbative diagnostic to measure the ion velocity distribution functions (IVDFs) of argon ions both parallel and perpendicular to the background magnetic field. We report ion beam formation as a function of the expansion chamber magnetic field (0-108 G). The ion beam appears peaked in the center of the expansion chamber and decays over a few centimeters radially. The LIF signal and ion beam velocity increase as the expansion field is decreased.

The ion beam decays with axial distance from the helicon source, which is in agreement with previous studies showing decreased LIF signal due to metastable quenching. We report the first perpendicular measurements of an ion beam formed from a CFDL. The perpendicular distributions show significant broadening in the radial center of the expansion region. For radial positions with no discernible ion beam in the parallel distribution, the perpendicular distributions have a high velocity non-maxwellian tail.

We also report the potential structure of the plasma obtained with an rf compensated planar Langmuir probe. To obtain meaningful Langmuir probe measurements, averages of tens of current-voltage are needed to reduce the effects of large electrostatic fluctuations that arise in plasmas that generate ion beams. We report the dependence of density, electron temperature, and floating potential on radial and axial position in the expansion plume. The density profile is radially hollow and peaks around 10-12 cm from the center.

Our measurements represent the most detailed analysis of ion beams downstream of a double layer. Future plans involve measuring the plasma potential with an emissive probe to negate the problems associated with Langmuir probes. We also plan to use optical tagging LIF to determine the spatial origin of the ions flowing downstream.