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

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Introduction
Presented here are 2-dimensional, spatially resolved LIF measurements in an expanding helicon plasma. We use laser induced fluorescence (LIF) to measure the ion velocity distribution functions (IVDFs) of argon ions, both parallel and perpendicular to the background magnetic field and an rf-compensated Langmuir probe to determine the local floating potential, electron temperatures, and the plasma density. All measurements were taken with an argon plasma with a pressure of 0.8-0.9 mTorr. The source magnetic field was 860 Gauss and the expansion field was 108 Gauss. Forward RF power was 750 Watts and the reflected power was 20 Watts. These measurements illuminate the physics of the plasma downstream of a double layer.

HELIX-LEIA Experimental Facility
- 61 cm long Pyrex tube
- 91 cm long stainless steel tube
- Source magnetic field 1200 Gauss
- 2 kW max rf
- 19 cm half wave helical antenna.
- π matching network
- 4.5 m long expansion chamber ID of 1.8 m
- Expansion magnetic field 120 Gauss

Mirror Ratio Shows Ion Beam Velocity Increases Non-Linearly With Decreasing Magnetic Field
- Ion beam velocity increases non-linearly from 8 km/s to 12 km/s
- Lower expansion field results in increasing LIF signal
- The beam and bulk populations become more pronounced as the field is lowered

Electron Density, Electron Temperature, and Floating Potential Show Field Aligned Structures
- RF compensated planar Langmuir probe.
- Large electrostatic fluctuations require many averages of I-V traces.
- Hollow density profile consistent with the LIF measurements of metastable ion density.
- Floating potential and electron temperatures show field aligned structures near the edge.

Summary
- The ion beam decays axially consistent with metastable quenching due to collisions.
- As the expansion field decreases, the ion beam velocity increases non-linearly.
- The downstream plasma is hollow and expanding (conic shape).
- The parallel IVDFs show a centrally confined, 8.5 km/s ion beam.
- The perpendicular IVDFs show, in the core, the field-aligned ion beam and the bulk, stationary ions outside of the plasma core. Near the source, nearly 1 eV ion temperatures are observed.
- The potential structure suggests multiple regions of different ion energization.

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