Ion Velocity Distribution Functions in a Compact, Expanding, Helicon Plasma

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Double Layers in Expanding Plasmas

Previous laser induced fluorescence (LIF) measurements of ion velocity distribution functions in a compact, expanding helicon plasma were limited by the available laser power and optical access [Kosec et al., Phys. Plasmas 12, 093502 (2005)]. Here we present LIF measurements of the IVDF in argon plasma in the CHEWIE compact helicon source as a function of fill pressure, source magnetic field, and partial pressure of argon. The LIF measurements were accomplished with a ring dye laser tuned to 611.6 652 nm (vacuum wavelength) to pump the Ar II 4s24p3D transition to the 4s24p5P state and observing the fluorescent emission at 652.0 nm photons. RF power up to 600 W is used to create a steady state plasma in the 12 cm long, 6 cm diameter Pyrex source chamber. One end of the source chamber is connected to a 30 cm long, 15 cm diameter expansion chamber. The magnetic field strength range s from 0 to 850 Gauss. We present measurements of argon IVDFs for various pressures and show evidence of an accelerated ion population.

Plasma Parameters in Upgraded CHEWIE Source

Above 200 Watts of forward power, there is a modest but distinct change in the visual appearance of the plasma and a small jump in the downstream plasma density. The electron temperature remains nearly constant at 5 eV.

High Pressure Case

At low pressures, spontaneous formation of electric double layers has been observed in expanding helicon source plasmas. Shown at right is a summary of laser-induced fluorescence (LIF) measurements of performed along the axis of the HELIX helicon plasma source. In the source region, the ions are at rest. In the expansion region, the pre-sheath and sheath regions of the double layer are evident and downstream of the source, a background population and an ion beam can be seen in the LIF measurements.

Summary

- Upgraded CHEWIE source produces spatially uniform downstream plasmas
- Large electrostatic instabilities arise at the largest magnet currents and at low neutral pressures.
- Parallel Ar II ivdfs measurements yield ion temperatures of ~ 0.5 eV and show clear evidence of an accelerated ion population downstream of the plasma source.

Ar II LIF Studies of Double Layer in Expansion Region

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