A Comparison of Laser Induced Fluorescence and Continuous Wave Ring Down Spectroscopy IVDF Measurements in an Argon Helicon Plasma

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Motivation
In this work, we compare two spectroscopic methods for measuring the ion velocity distribution functions (IVDF) in an argon helicon plasma: laser induced fluorescence (LIF) and continuous wave cavity ring down spectroscopy (CW-CRDS). An established and powerful technique, LIF suffers from the requirement that the initial state of the LIF sequence have a substantial density. In most cases, this requirement limits LIF to ions and atoms with large metastable state densities for the given plasma conditions. CW-CRDS is considerably more sensitive than LIF and can potentially be applied to much lower density populations of ion and atom states. CRDS is a line integrated technique without the spatial resolution of LIF. CRDS is a proven, ultra-sensitive, cavity enhanced absorption spectroscopy technique and when combined with a CW diode laser that has a sufficiently narrow linewidth, the Doppler broadened absorption line, i.e., the IVDF, can be measured. We present CW-CRDS and LIF measurements of the IVDF in an argon plasma using the 668.614 nm (in vacuum) line of Ar II.

Experimental Apparatus: CHEWIE
Compact HEIcon Waves and Instabilities Experiment

Experimental apparatus including the compact tapered amplified diode laser, the acousto-optic modulator used for rapid extinction of the laser light, and the beam shaping and beam steering optics. On the right is the CHEWIE plasma source (including the chamber sections which house the internal mirrors that make up the resonant optical cavity) in the center and the data acquisition system.

CRDS Experimental Configuration

Perpendicular IVDF Measurements with CW-CRDS in CHEWIE

Doppler broadened absorption profile of Ar II
Ion temperature = (0.09 ± 0.02) eV

Parallel IVDF Measurements with LIF in CHEWIE

Tunable Diode Laser
Ion temperature = (0.53 ± 0.02) eV

1 Watt Tunable Dye Laser
Ion temperature = (0.21 ± 0.02) eV

Summary
- Continuous Wave Cavity Ring Down Spectroscopy is being developed as a plasma diagnostic tool to measure vdfs of ion and neutral species when the initial state density is too small for conventional LIF.
- LIF measurements of parallel IVDFs yield significantly warmer measurements of than the line integrated perpendicular measurements 5 cm downstream of the LIF measurement location.
- The two different parallel LIF measurements yield ion temperatures that differ by a factor of two. Additional studies are needed to understand the differences in the diode and dye laser based LIF IVDF measurements.

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