Cavity Ring Down Spectroscopy Measurements of Ar-II Velocity Distribution Functions

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Abstract - Motivation

The WVU helicon source group routinely uses laser induced fluorescence (LIF) to measure the ion velocity distribution function (ivdf) of argon plasmas. We are constructing a continuous wave Cavity Ring Down Spectroscopy (cw-CRDS) system that will provide an alternate approach to measuring the ivdf. CRDS is a proven, ultra-sensitive, laser absorption technique that will provide sufficient resolution to measure the Doppler broadened absorption line of Argon and other plasma species. We will use a CW tunable diode laser at 668.43 nm, pumping the Ar-II metastable 3p^2P_o state to the 4p^2P_o level, to gather data from our steady state, high density, helicon plasma source CHEWIE (the Compact Helicon Waves and Instabilities Experiment). The cw-CRDS data will then be compared to LIF measurements. Once optimized for the Ar-II transition, we will use a similar experimental configuration to complete the difficult measurement of the ivdf for He-II transition at 1012.36 nm. This report will present completed design schematics for the CRDS system as well as initial data gathered through the early stages of operation.

CHEWIE Experimental Apparatus

[Compact Helicon Waves and Instabilities Experiment]

PORTABLE COMPACT CW-CRDS MOUNTS

The MIRROR Mount

LIF with a Tunable Diode Laser at ~ 668 nm

Ar-I LIF Scheme

Ar-II LIF Scheme

He-I LIF Scheme

Typical LIF ivdf Measurements

The Target He-II Transitions

Shown below is an emission spectroscopy measurement obtained by Kessler and Roessler using a liquid-nitrogen-cooled bellow cathode helium lamp. The transitions are labeled as shown in the Grotthuss diagram [on the right] for the 19 levels. Preliminary absorption measurements (shown at bottom right) using a single pass optical system and a lock-in-amplifier were encouraging but irreproducible.

Summary

- Continuous Wave Cavity Ring Down Spectroscopy is being developed as a plasma diagnostic for ivdf measurements on ion and neutral species that are too low in density for standard LIF to work.
- Initial results from table-top experiments show successful cavity mode matching
- Tracking circuit is built and tested
- First field trials will be with Ar ion ivdf measurements in the Helicon plasma source CHEWIE

Experimental Schematic

[PH] => Pinhole; L => Lenses for spatial filtering; HM => High Reflective Mirrors; LIF => Laser Induced Fluorescence; CRDS => Cavity Ring Down Spectroscopy

Tracking Circuit

Threshold Detector

Pulse Generator

Data Acquisition

Oscilloscope Traces

Examples of Cavity Mode Matching

PZT => Piezoelectric Transducer; AOM => Acousto-Optic Modulator; [10 kHz]; PZT => Piezoelectric Transducer [kHz]; Tracking Circuit

Note: The image contains diagrams and graphs related to the experimental setup and data analysis, including absorption coefficients, emission spectra, and signal traces.