**Continuous Wave Cavity Ring Down Spectroscopy Measurements of Ion Velocity Distribution Functions in Argon Helicon Plasma**

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**Abstract - Motivation**

The West Virginia University helicon source group routinely employs laser induced fluorescence (LIF) to measure velocity distributions of argon ions, argon neutrals, helium neutrals and xenon ions. LIF is an effective and versatile technique as long as sufficiently large populations of the target species are available. Thus, the target state is typically a metastable state. For electronic states that are much less populated, we are developing a continuous wave cavity ring down spectroscopy (CW-CRDS) diagnostic with a narrow linewidth, tunable diode laser as an alternative to conventional LIF. CRDS is a proven, ultra-sensitive, cavity enhanced spectroscopic technique and the CW diode laser has sufficiently narrow linewidth to be able to resolve the Doppler broadened absorption line of argon and other plasma species. We will present initial measurements of the Ar-II ion velocity distribution function obtained through measurements of the absorption spectrum of Ar-II at 668.614 nm (in vacuum), as a standard initial state for conventional Ar-II LIF. The excitation at 668.614 nm pumps the Ar-II metastable 3d4F7/2 level to the 4p4D5/2 level.

**Experimental Scheme**

**Experimental Apparatus:** CHEWIE

**Continuous Wave Cavity Ring Down Spectroscopy**

**Basic Principle**

\[ \tau = \frac{d}{c - R_{ab} + \beta_{scat}d + \beta_{abs}d + \text{absorbance}} \]

The absorbance can be calculated:

\[ \text{Absorbance} = \alpha \tau n x \frac{1}{c} \frac{1}{\tau} \]

where \( d \) is the effective length of absorption in plasma, \( l \) is the length of the cavity, \( \beta \) is the broadband scattering coefficient, \( \alpha \) is the absorption cross section at the wavelength of measurement, \( n \) is the line of sight integrated density of the metastable ions; \( \tau_0 \) incorporates all the background losses in the absence of any plasma.

**Summary:**

- **Continuous Wave Cavity Ring Down Spectroscopy is being developed as a plasma diagnostic tool to measure vdf of ion and neutral species when the density is too low for conventional LIF to work.**
- **The CW-CRDS set up has been successfully tested in air and vacuum.**
- **Portable compact CW-CRDS mounts have been installed in CHEWIE.**
- **Initial measurements of Ar-II absorption at 668.6138 nm are just above the noise floor.**

**Calculated R_{eff} = 99.976%**

**Examples of Ring Downs for various cavity lengths**

**CW-CRDS in CHEWIE**

**Experimental Scheme**

**Experimental Scheme**

**Details of the Tracking Circuit**

**Data Acquisition**

**Tracking Circuit**

**Photodiode**

**Signal From Generator**

**Tracking Circuit**

**PZT driving signal**

**Oscilloscope Traces**

**CW-CRDS in CHEWIE**

**Examples of cavity mode matching and the corresponding trigger signals generated to shut the AOM and record ring down data.**

**Calculated absorption cross section for Ar-II transition at 668.6138 nm = 10^{-4} cm^2.**

**Experimentally expected detection threshold of absorption coefficient \( \alpha \approx 10^8 \text{cm}^{-1} \).**