Laser Induced Fluorescence Measurements of Argon Neutrals in Two Helicon Sources

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Introduction

A laser induced fluorescence (LIF) scheme to measure velocity distribution functions (VDFs) of argon neutrals was previously developed by the West Virginia University helicon source group [Keesee et al., 2009]. The scheme is shown in blue, with our current Ar I LIF scheme shown in red for comparison.

Collection locations

Collection A: 2-0 Collection Stage
Collection B: Optics in Viewport
Collection C: Re-entrant Probe

Laser injection

Laser controller

To spectrometer

Chopper

Laser-induced fluorescence (LIF)

$f(v) = n [\exp \left( \frac{v}{2.2\mu m/s} \right) - \exp \left( \frac{v}{2.2\mu m/s} - 2.4\mu m/s \right)]$

While the initial state in the Ar II LIF scheme is metastable, this is not true for the Ar I scheme. This state must be populated by collisions with atoms in two nearby metastable states (MS). Thus, this scheme is highly dependent on neutral pressure. With parallel (to the axial magnetic field) injection of the laser, two sets of lines (Zeeman splitting) will be pumped, yielding two Doppler-broadened Gaussian line shapes. The spacing of the two Gaussians will vary with magnetic field ... in frequency space of the midpoint between the peaks can be used to determine the bulk velocity of the population.

Pressure

5.8-5.9 mTorr

2.2-2.5 mTorr

1.9 mTorr

1.1-1.3 mTorr

Pressures are shown in blue, with our current Ar I LIF scheme shown in red for comparison.

Discussion and Future Work

We initially tried Ar I LIF with fiber injection, but did not achieve reliable signal/noise levels. We obtained excellent signal/noise levels at a wide range of pressures with direct injection of the laser. We originally tried to detect neutral flow at the re-entrant probe (location C), but were unable to achieve good neutral signal at the low pressures required for high ion flow. Then we tried to detect neutral flow at the last source viewpoint (location B). It is likely that a background population with no flow and a population of fast neutrals would be present, with the fast population having lower density and, thus, lower LIF signal magnitude. We tried to find a pressure at which ion flow was present and such a neutral population would be detectable, but were not successful. It is possible that this fast population of neutrals exists, but due to the multiple collisions required (ion-neutral collision to transfer momentum, collision to populate initial state of LIF scheme from MS states), we may not be able to detect that population with this LIF scheme. Using a dye laser system that we currently have with an alternate dye, we could try a scheme that pumps from a metastable state [Aramaki et al., 2009]. The scheme is shown in blue, with our current Ar I LIF scheme shown in red for comparison.

We had originally planned to perform LIF on our smaller helicon source, CHEWIE (Compact Helicon Waves and Instabilities Experiment). Due to time constraints and concurrent experiments to establish a two-photon absorption LIF (TALIF) diagnostic for hydrogen, we were unable to perform such measurements. Those measurements will be attempted in the future.