**COMPARISON OF ESTABLISHED AND NOVEL LASER-INDUCED FLUORESCENCE SCHEMES FOR Ar-I**

Zachary D. Short, M. Umar Siddiqui, Miguel F. Henriquez, John S. McKee, Julianne M. McIlvain, Earl E. Scime, Amy M. Keesee, and Drew B. Elliott

Department of Physics and Astronomy, West Virginia University

**SUMMARY**

To explore ion-neutral coupling in plasmas, it is advantageous to be able to measure the velocity distribution function (VDF) of ions and neutrals simultaneously at a single spatial location. While in previous experiments we have successfully performed neutral and ion VDF measurements with a single laser, the Ar-I laser induced fluorescence (LIF) scheme used was limited to operational regimes that were unsuitable for LIF measurements of Ar-I. Here we describe a novel infrared LIF scheme for Ar-I using a Sacher tunable diode laser and compare it to the previous Ar-I LIF scheme [Keesee et al. Rev. Sci. Instrum. 75, 4091 (2004)]. In contrast to the previous method, our LIF scheme collects emission light that has no other natural argon emission lines nearby, decreasing the non-signal radiation collected by the detector and thereby reducing the noise background.

**PRINCIPLES OF LIF**

- LIF utilizes a laser to pump an atomic species to a higher energy state.
- The excited state relaxes to a third state.
- The intensity of the resultant emission is proportional to the density of the absorber and, plotted against laser frequency, yields an absorber state distribution function in the laser frequency/absorber velocity space.

**LIF SCHEMES**

Old 1s4 Ar-I LIF scheme
- 667.913 nm pump photon.
- Emits a 750.590 nm photon.
- The decay line is <1 nm away from another strong line.

Novel 1s2 Ar-I LIF scheme
- 841.062 nm pump photon.
- Emits a 726.913 nm photon.
- No other strong emission lines nearby.

**EXPERIMENTAL APPARATUS**

**1s_2 AND 1s_4 LIF SCHEMES MEASUREMENTS**

**FIG. 3.** Experimental setup for LIF measurements of 1s2 state of argon with the Sacher oscillator. This laser injected up to 28 mW.

**FIG. 4.** Experimental setup for LIF measurements of 1s4 state of argon with the Toptica MCPA laser. This laser injected up to 150 mW.

**FIG. 5.** Scans for 1s4 scheme over rf power and neutral pressure show that:
- With an rf power of 400 W, the best SNR was measured at 7.0 mTorr.
- With a neutral pressure of 8.0 mTorr, the best SNR was measured at 300 W.

With the 1s2 scheme, we performed five 0.5 GHz scans near the pump line and patched them together, as shown in Figure 6(a). Each scan yielded SNR > 18, with a max at 18.7. The red line in Figure 5 indicates the maximum SNR for the 1s2 scheme.

- The max 1s4 SNR was 18.5 for 150 mW.
- The max 1s2 SNR was 18.7 for 28 mW.
- What caused the improvement in SNR/laser power?
  a. larger population yielding a higher absolute signal level
  b. reduced background noise level
- The 1s4 noise level must be reduced by
  > 125:28 = 4.5, the ratio of laser powers.

**FIG. 6.** (a) Patched 1s2 NVDF. Each color represents a different scan at a different center frequency, and (b) fit to a 0.054 eV Gaussian distribution.

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**KEY RESULTS**

- Our 1s2 scheme exhibits a reduced background noise level and/or a larger neutral population than the 1s4 scheme for typical plasma parameters.
- Equivalent SNR was achieved with < 1/4 laser power of previous scheme.