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ARGON DYNAMIC OPTOGALVANIC SPECTRUM IN HOLLOW CATHODE DISCHARGE

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Abstract. Argon dynamic optogalvanic spectrum in 450-471nm range is recorded in hollow cathode discharge. Qualitative interpretation of the signals shape is discussed.

1. INTRODUCTION

The optogalvanic effect represents the plasma conductivity change as a result of resonant light absorption (Barbieri 1990). The population of the levels belonging to the illuminated optical transition is changed by the absorption of the resonant quanta. This disturbs the ionization rate which causes variations in the discharge tube impedance. The optogalvanic technique has been most widely used for wavelength calibration of the spectra and for frequency and power stabilization of the lasers. Recently the dynamic optogalvanic signals are applied for obtaining of some plasma parameters by fitting the modeled dynamic signals with the experimentally registered signals.

The hollow cathode lamps turned out to be favorable optogalvanic detectors due to their rich spectra which include the emitted spectral lines from highly excited levels of both the working gas and the sputtered atoms of the cathode materials. The buffer gases in the hollow cathode lamps become advantageous by providing simultaneous calibration spectra. The use of dynamic optogalvanic signals turns out to be extremely interesting since these signals are described not only by their amplitude and sign (as the stationary optogalvanic signals are), but also by their positive and negative time components. They could also contain additional components originating from the sputtered material, damped oscillations, etc.

In this work, Ar dynamic optogalvanic spectrum in 450-471nm region is being registered in a hollow cathode discharge for the purpose of wavelength calibration applications. Ar dynamic optogalvanic spectra in this range are recorded in (Gusev 1987) and (Reddy 1990). In the first paper the Ar spectrum is not measured in hollow cathode discharge. In the second it is measured in hollow cathode discharge but the optogalvanic signal amplitudes are not shown.

2. EXPERIMENTAL

The hollow cathode with 3mm diameter and 8mm length represents an Al cylinder without a bottom. The optimal Ar pressure is 6Torr. The 0.1mm laser light beam illuminates the hollow cathode discharge along its axis and is centered in the negative glow region. The pulse dye laser (Sopra LCR1 pumped by the third harmonics of Nd:YAG laser Power Lite 700) has 5ns temporal width, 10Hz frequency and 80μJ pulse energy. The light is tuned to the 450-470nm spectral range. The dynamic optogalvanic signals are recorded using a two-channel digital real-time oscilloscope (Le Croy 9361) and are then processed by a computer.

3. RESULTS AND DISCUTION

Dynamic optogalvanic signals relevant to Ar atomic optical transitions in 450-471nm spectral range are registered as function of the discharge current (i). The Ar optogalvanic spectrum is demonstrated in Table 1.

Table 1: Ar dynamic optogalvanic spectrum registered in 450-471nm range

Wavelength [nm]	Configurations	Terms	OGS [mV]
451.07	$3s^23p^5(^2\mathrm{P}^\circ{}_{1/2})4s$–$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})5p$	$^2[^1/_2]$ - $^2[^1/_2]$	25
452.23	$3s^23p^5(^2\mathrm{P}^\circ{}_{1/2})4s$ - $3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})5p$	$^2[^1/_2]$ - $^2[^1/_2]$	35
454.47	$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})4p$– $3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})11d$	$^2[^1/_2]$ - $^2[^1/_2]$	18
455.43	$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})4p$–$3s^23p^5(^2\mathrm{P}^\circ{}_{1/2})7d$	$^2[^1/_2]$ - $^2[^3/_2]$	20
458.49	$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})4p$– $3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})10d$	$^2[^1/_2]$ - $^2[^3/_2]$	20
458.66	$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})4p$– $3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})10d$	$^2[^1/_2]$ - $^2[^1/_2]$	15
458.72	$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})4p$ -$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})10d$	$^2[^1/_2]$ - $^2[^1/_2]$	22
458.93	$3s^23p^5(^2\mathrm{P}^\circ{}_{1/2})4s$–$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})5p$	$^2[^1/_2]$ - $^2[^3/_2]$	20
459.61	$3s^23p^5(^2\mathrm{P}^\circ{}_{1/2})4s$–$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})5p$	$^2[^1/_2]$ - $^2[^3/_2]$	40
462.84	$3s^23p^5(^2\mathrm{P}^\circ{}_{1/2})4s$– $3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})5p$	$^2[^1/_2]$ - $^2[^5/_2]$	12
464.21	$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})4p$ -$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})9d$	$^2[^1/_2]$ - $^2[^3/_2]$	10
464.75	$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})4p$– $3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})9d$	$^2[^1/_2]$ - $^2[^1/_2]$	10
470.23	$3s^23p^5(^2\mathrm{P}^\circ{}_{1/2})4s$–$3s^23p^5(^2\mathrm{P}^\circ{}_{3/2})5p$	$^2[^1/_2]$ - $^2[^1/_2]$	15

The dynamic optogalvanic signals with maximum amplitude correspond to the 452.23nm (Fig.1) and 459.61 optical transitions. The shapes and time dependences of the other DOGSs registered are similar, so they differ only in their amplitudes. This could be explained by taking into account that their upper levels are very close. The first component of the signal can be understood as a decrease of the impedance in the discharge due to the increased population of the upper levels which can be much easier ionized. The next part of the DOGS reveals the relaxation behavior of the disturbed plasma. It is seen in Fig. 1 that the DOGS amplitudes increase and their width decrease at growing values of the discharge current.

The dynamic optogalvanic signal corresponding to the 451.07nm transition is the only one whose first component is negative (Fig. 2). The qualitative understanding of this signal shape could be associated with the extremely long time (10^{-2}s) of the

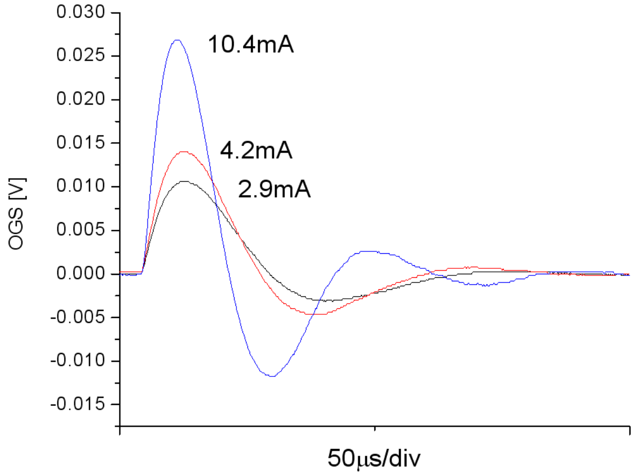

Figure 1: Dynamic optogalvanic signal corresponding to Ar I 452.23nm optical transition as function of the discharge current.

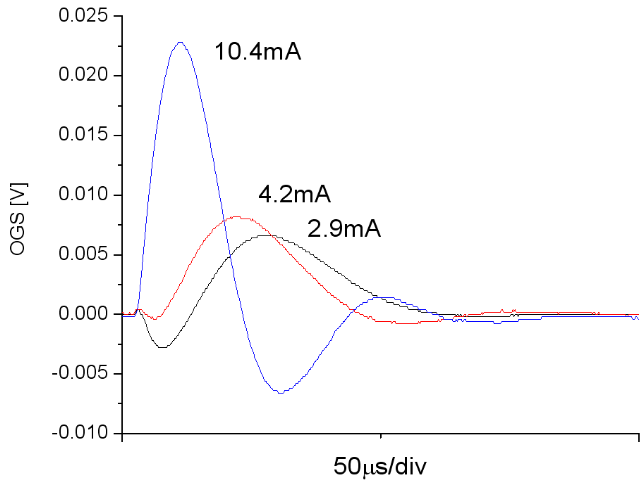

Figure 2: Dynamic optogalvanic signal corresponding to the Ar I 451.07nm optical transition as function of the discharge current.

lower energetic level of this transition. This lower state obviously plays a significant role in the ionization in the hollow cathode plasma especially at lower discharge current values. In this case, the depopulation of this long living level resulting in the decreased ionization could not be compensated by the increased ionization from the higher level of the transition. The amplitude of this component decreases with the discharge current and it is transformed into positive component at i $>$ 5mA. The interpretation of this result is complicated. This could be related to the increased particle concentration in the hollow cathode plasma at higher discharge current values followed by higher frequencies of particle interactions. It means that in this case the contribution of the ionization from the other excited levels becomes crucial.

4. CONCLUSION

The Ar dynamic optogalvanic spectrum recorded in 450-471nm spectral range enriches the atlas of the Ar optogalvanic markers useful for wavelength calibration. The dynamic optogalvanic signal related to the 451.07nm is the only signal starting with a negative component in the spectral region of interest. The results obtained could be also applied in hollow cathode plasma modeling.

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