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DYNAMIC OPTOGALVANIC KRYPTON AND NEON SPECTRA FOR 428-451nm RANGE IN HOLLOW CATHODE DISCHARGE

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Abstract. Dynamic optogalvanic Kr and Ne spectra in 428-451nm range are recorded in Kr and Ne hollow cathode lamps for calibration purposes.

1. INTRODUCTION

Some of the most widely used optogalvanic spectroscopy applications include wavelength calibration and frequency and power laser stabilization. The development of tunable lasers, capable nowadays of generating in various spectral ranges, requires the availability of new relevant optogalvanic spectra. The optogalvanic effect is a change in plasma conductivity caused by resonant light absorbed by different discharges (Foote 1925, Barbieri 1990). The combination of the optogalvanic effect with the hollow cathode glow discharge turns out to be very useful due to the availability of a great number of commercial hollow cathode lamps emitting rich and stable spectra of different materials. The dynamic optogalvanic signals (DOGS) represent plasma reaction after absorption of a short ($\sim$ns) laser pulse. Compared with the stationary type optogalvanic signal, the DOGS is characterized not only by its amplitude and sign, but also by its time dependence shape and peculiarities. For this reason, the DOGSs can be used in many cases as explicit markers for the purposes of wavelength calibration, plasma diagnostics, etc.

In this work a great number of Kr and Ne DOGSs in 428-451nm range have been registered in Kr and Ne hollow cathode lamps. No data have been found for Kr optogalvanic spectra so far in the optogalvanic spectroscopy literature, except for reports of registrations of few particular signals. For example, the optogalvanic signal of Kr corresponding to 826.32nm transition has been recorded for comparison purposes when an AlGaAs diode laser has been frequency stabilized to an U I transition using optogalvanic effect in hollow cathode discharge (David 1990). For the aims of plasma diagnostics the shape of the three Kr DOGSs (556.2nm, 557.0nm, 567.2nm) related to its metastable levels, have been used recently (Piracha 2007). Neon DOGSs registered in Ne hollow cathode lamp for the above mentioned range are published (Bezlepkin 1988, Reddy 1991) but their time dependences are not shown and there are no data for the DOGSs amplitude (Reddy 1991).

2. EXPERIMENTAL SET-UP

The hollow cathodes have the shape of 10mm and 15mm long cylinders with diameters of 3mm and 6mm for the Kr and Ne hollow cathode lamps, respectively. Spectrally pure Kr and Ne are used as working gases at the pressure of about 4Torr. The discharge current (i) is changed from 1mA to 12.4mA. The hollow cathode discharge is illuminated by a pulsed (5ns, 10Hz frequency) dye laser (Sopra LCR1 pumped by Nd:YAG laser), tuned to the 428-451nm wavelength range. The laser power is varied within the range of 1.2 - 2.6mW. The incident laser beam passes along the cathode axis and illuminates both the hollow cathode plasma and the cathode bottom. The DOGSs of the Kr and Ne optical transitions are recorded as function of i using a two-channel digital real-time oscilloscope (Le Croy 9361) and processed by a computer.

3. EXPERIMENTAL RESULTS AND DISCUSSION

A great number of dynamic optogalvanic signals relevant to many Kr atomic optical transitions between $5s$ low levels and highly excited $6p$, $8p$ and $5f$ levels, situated very close to the Kr ionization potential, are registered in the 428-451nm range. The Kr DOG spectrum is demonstrated in Table 1 and a typical dynamic optogalvanic signal shape is shown in Fig. 1.

Dynamic optogalvanic signals relevant to many Ne atomic optical transitions between $3p$ low levels and different highly excited ns and nd levels situated very close to the Ne ionization potential are presented in Table 2 and a typical dynamic optogalvanic signal shape is shown in Fig. 2.

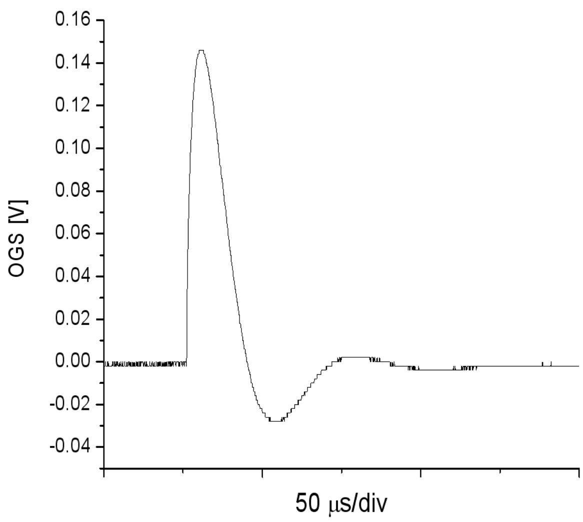

Figure 1: Dynamic optogalvanic signal corresponding to Kr I 439.99nm optical transition at 10mA discharge current and 2mW laser power.

The rich optogalvanic Kr and Ne spectra with high amplitudes obtained here is due to the very important advantage of the hollow cathode plasma, namely, the dense population of the higher energy atomic levels. The main reason is the special shape of the electron energy distribution function, having a large plateau of higher energy electrons.

The dynamic optogalvanic signals have sinusoidal shape (Figs. 1 and 2). As signal amplitude value of the DOGS is taken the first component. This component is interpreted as a result of the impedance decrease in the discharge. In our case it is due to the increased population of the upper levels, which can be much easier ionised by low energy electrons than the origin levels. The next part of the DOGS reveals the relaxation behaviour of the disturbed plasma. It depends not only on the characteristics of the two levels coupled in the transition, but also on the discharge conditions, tube design and parameters of the electrical circuit.

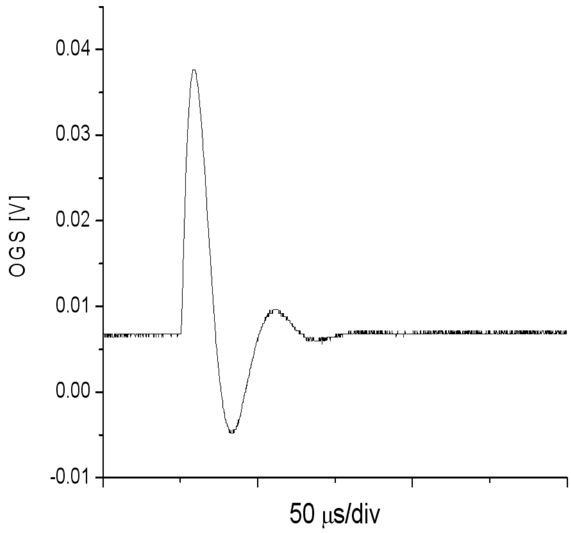

Figure 2: Dynamic optogalvanic signal corresponding to Ne I 436.35nm optical transition at 8mA discharge current and 1.2mW laser power.

Table 1: Krypton dynamic optogalvanic spectrum registered in the 428-451nm range at 10mA discharge current and 2mW laser power

Wavelength [nm]	OGS [mV]	Wavelength [nm]	OGS [mV]
427.396	100	439.996	200
428.296	50	441.036	100
428.648	120	441.239	20
430.048	140	441.688	65
430.244	60	441.876	100
431.855	100	442.519	130
431.957	160	445.391	70
435.135	110	446.369	60
436.264	80	450.235	40
437.612	70		

Table 2: Neon dynamic optogalvanic spectrum registered in the 428-451nm range at 8mA discharge current and 1.2mW laser power

Wavelength [nm]	OGS [mV]	Wavelength [nm]	OGS [mV]
427.927	4	441.356	4
428.324	4	441.681	8
430.324	5	442.252	15
430.625	4	442.480	15
431.469	8	442.540	10
431.600	6	442.775	4
432.726	5	443.251	10
433.412	4	443.372	20
434.335	4	444.154	5
434.603	7	444.497	8
435.791	5	445.298	7
436.352	23	445.556	4
437.215	5	446.017	15
437.525	6	446.652	4
438.122	10	446.565	8
439.555	10	446.681	12
440.278	5	447.565	5
440.364	5	448.319	5
440.962	5	448.809	7
441.228	5	450.018	2

4. CONCLUSION

Krypton and Neon dynamic optogalvanic spectra are registered in the 428-451nm range for Kr and Ne hollow cathode lamps. DOGS amplitude values and time shapes are obtained. Since there were no Kr optogalvanic spectra found in the literature, the one registered in this work compensates for this omission. The Ne optogalvanic spectra registered extends the Ne DOGS atlas.

These results can be used for calibration purposes and for Kr and Ne plasma modeling in hollow cathode discharge.

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