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Collisional rate parameters for the $1s_4$ energy level of neon 638.3 nm and 650.7 nm transitions from the analyses of the time-dependent optogalvanic signals

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Abstract. A mathematical rate equation model using a Monte Carlo simulation has been used to analyze the laser optogalvanic signals of neon waveforms excited at 638.3 nm and 650.7 nm and arising from the $1s_4$ state transitioning to $2p_7$ and $2p_8$ states, respectively. The decay rates have been determined for the directly involved $1s_4$ state and also for the indirectly involved $1s_2$ and $1s_5$ states. There is good agreement among the decay rate constants found and they show a predominantly linear variation with increasing current.

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Key words: optogalvanic effect, Monte Carlo least-square fitting, collisional rates

1 Introduction

Laser optogalvanic spectroscopy has been established as an application tool for the measurements relating to ion mobility, atomic and molecular spectroscopy, ionization rates, and recombination rates, in the determination of velocity of particles and as a combustion probe for trace element detection. Optogalvanic (OG) effect is the change in the electrical impedance of plasma caused by resonant absorption of optical radiation by a plasma [1,2]. In the OG effect there is no problem of overlap from background emissions, and hence weak signals can be detected with a high signal to noise ratio, which makes this technique a very sensitive one to resolve vibrational changes in molecular bonds.

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Literature survey reveals that libraries of the OG transitions for neon are available in the visible region, and for argon in the UV region [3, 4]. There also exists a rate equation model [5–7] for the optogalvanic effect produced by tunable laser excitation of the neon 1s states in the positive column of a normal glow discharge. This model identifies quantitatively the dominant effects of electron collisional transfer and radiation wall losses and uses a non-linear least squares fitting procedure to obtain the relevant parameters. Recently we have utilized the Monte Carlo least-squares fitting method [8]to generate an accurate equation for modeling the OG waveforms. In the present study, a Monte Carlo fitting of the OG waveforms of neon associated with the $1s_4-2p_7$ transition at 638.3 nm and the $1s_4-2p_8$ transition at 650.7 nm for a variety of current values in the range 2-19 mA was utilized to understand the collisional processes and to estimate the parameters involved therein.

2 Experimental

The experimental set-up is shown schematically in Fig. 1.

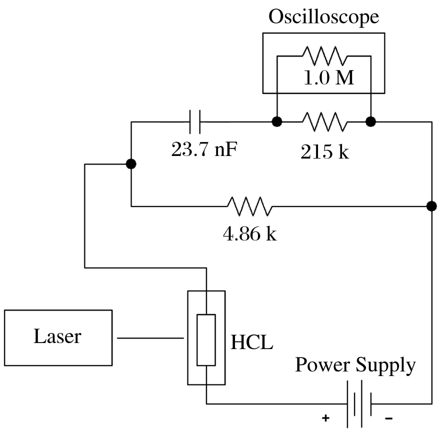

Figure 1: Schematic experimental arrangement for laser optogalvanic spectroscopy using a hollow cathode discharge lamp (HCL).

A pulsed laser (of typical pulse width 5 ns) is tuned to either the neon 638.3 nm or the 650.7nm transition and directed to enter a hollow cathode discharge lamp (”the galvatron” HCL) containing a mixture of Ne and CO gases. The galvatron is coupled in series with a current-limiting RC circuit, and the discharge current (2-19 mA) is controlled by adjusting the voltage on the power supply. The OG signal (deviation of the discharge current from its steady state DC value as a function of time) is displayed on a digital oscilloscope (Tektronix TDS 224; input impedance = 1.0 MΩ) and averaged over 256 pulses. The stored data is used for further analysis using a Monte Carlo fitting routine [7].