Publ. Astron. Obs. Belgrade No. 102 (2022), 195 - 198 *Contributed Paper*

POLARIZATION SPECTROSCOPY OF NEON LINES FOR ELECTRIC FIELD DISTRIBUTION MEASUREMENT IN THE CATHODE SHEATH OF A GRIMM-TYPE GLOW DISCHARGE

N. V. IVANOVIĆ[1], N. V. NEDIĆ[2], I. R. VIDENOVIĆ[2] and D. SPASOJEVIĆ[2]

[1]*University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Belgrade, Serbia.*

[2]*University of Belgrade, Faculty of Physics, P.O.Box 44, 11001 Belgrade, Serbia*

E-mail nikolai@agrif.bg.ac.rs

Abstract. We report on the results of the experimental study of Ne I 508,038 nm spectral line along the cathode sheath region of an abnormal glow discharge operated in neon with a small admixture of hydrogen. The line was recorded using the Stark polarization spectroscopy technique. The value of coefficient *C*, correlating the Stark shift of sigma (σ) polarized components and electric field strength, was determined and can be further used for electric field strength measurements.

1. INTRODUCTION

Atomic neon spectral lines behavior in external electric fields have been the subject of many experimental and theoretical studies (Ryde 1976, Jäger and Windholz 1984, Windholz and Neureiter 1988, Jäger at al. 1989, Ziegelbecker and Schnizer 1987). Recently, simple methods based on the analysis of the low-field quadratic Stark effect on neon lines have been developed for mapping the electric field distribution in the cathode sheath (CS) of the Grimm-type abnormal glow discharge (Majstorović at al. 2013, Šišović et al. 2014, Ivanović et al. 2017) The complex structure of the Ne I 508.038 nm spectral line was also identified (Ivanović, 2019), but so far was not studied in detail. In this work we demonstrate the use of polarized spectroscopy of the Ne I 508.038 spectral line against the known electric field strength, for determination of its shift coefficient C, so that it can be further used for the measurement of the electric field distribution in the CS.

2. EXPERIMENTAL SETUP

A modified glow discharge source was laboratory-made following the design proposed by Ferreira et al. 1980, and described in detail elsewhere (Kuraica et al. 1992, Majstorović at al. 2013, Šišović et al. 2014, Ivanović et al. 2017). The hollow anode (30 mm long with 8 mm inner diameter) has a longitudinal slot (16 mm long and 1.5 mm wide) for side-on observations along the discharge axis. The water-cooled cathode holder has an exchangeable tungsten electrode, 18 mm long and 7.40 mm in diameter.

Spectroscopic observations were performed side-on through the anode slot, in translation steps along the discharge axis of approximately 1/16 mm. The radiation from the discharge was polarized before entering the spectrometer by orienting the polarizer axis parallel or perpendicular to the discharge axis. The π-polarized component of light is linearly polarized along the electric field direction, while the σ-polarized component is circularly polarized in the plane perpendicular to the electric field. The recordings of the unpolarized profiles were carried out without the polarizer.

The radiation from the discharge is focused with an achromatic lens (focal length 75.8 mm with unity magnification) onto the 20 μm entrance slit (height restriction 2 mm) of the 2 m focal length Ebert-type spectrometer with 651 mm^{-1} reflection grating blazed at 1050 nm. The reciprocal dispersion of 0.37 nm mm^{-1} is used throughout this experiment. All spectral measurements were performed with an instrumental profile close to a Gaussian with the measured full width at half maximum (FWHM) of 8.2 pm in the second diffraction order. The signals are collected by a computer-driven CCD detector (1 x 3648 pixels, 8 μm pixel width).

3. EXPERIMENTAL SETUP

Figure 1 shows three profiles, with different polarization, of the Ne I 508.038 nm spectral line observed at the same position in the CS region. The unpolarized profile, denoted with a black line, is comprised of an unshifted component and three Stark components. The unshifted component, originated from the part of the discharge protruding through the anode slot, is emitted from the zero-field region and appears in the recorded spectra as an unshifted peak that enables us to measure the Stark shifts against it.

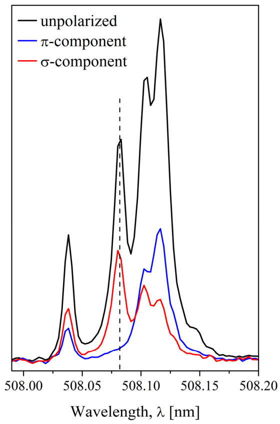

Figure 1: Unpolarized and polarized profiles of the Ne I 508.038 nm spectral line, recorded at the same axial position in the CS region.

The σ-polarized profile features an unshifted peak and one clearly separated Stark component (dashed line). Two additional peaks at the red side are not clearly separated at lower electric fields, and therefore were not considered in the fitting process.

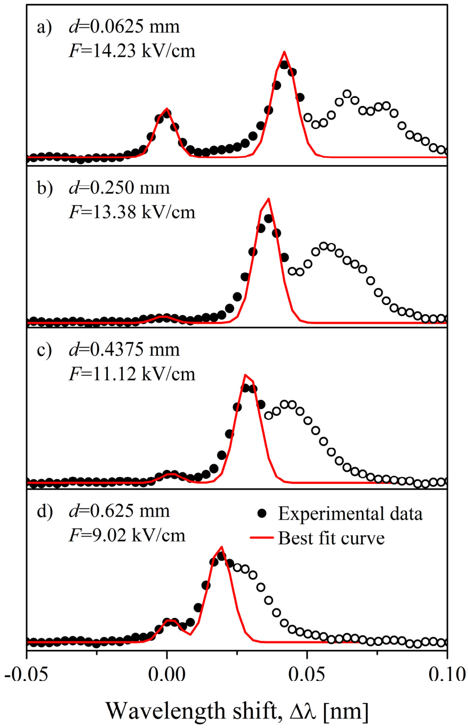

Figure 2: Experimental profiles of the Ne I 508.038 nm spectral line (dots) and their best-fit (red) curves. Hollow experimental points were discarded in the fitting process.

The profiles of the Ne I 508.038 nm spectral line recorded side-on at four different axial positions along the CS region are depicted in Fig. 2. The values of electric field at these positions are determined using the Stark shift measurements of the Ne I 507.420 nm spectral line and the calibration curve of its Stark shifts, see Ivanović et al. 2017. Upon the fitting procedure, the Stark shifts of the Ne I 508.038 nm σ-polarized component were measured relative to the unshifted component using the model function explained in detail by Ivanović et al. 2017.

The Stark shifts determined with the foregoing numerical procedure are presented in Fig. 3. The red solid line was obtained by the equation (4) given by Jäger and Windholz 1984, which in the case of small electric fields reduces to:

$$\Delta\lambda = -\lambda_0^2 C F^2 \ , \tag{1}$$

where λ_0 = 508.038 nm, yielding the C coefficient value of -0.00827 kV^{-2}cm.

4. CONCLUSION

We present a Stark polarization spectroscopy study of the Ne I 508.038 nm spectral line profiles, recorded in the cathode sheath region of the Grimm-type abnormal glow discharge. The value of the coefficient C, correlating the Stark shift of the σ-polarized component and the electric field strength, is determined. These results expand the list of neon atomic spectral lines that can be used in spectroscopic diagnostics of the electric field strength.

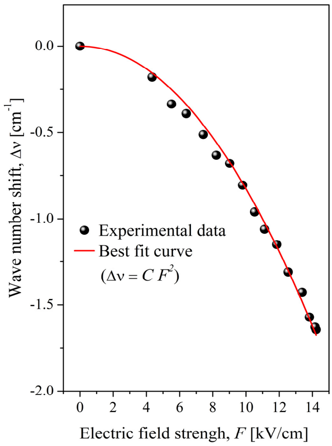

Figure 3: Dependence of the wavenumber Stark shift Δν for the Ne I 508.038 nm spectral line on the electric field strength F.

Acknowledgments

This work is supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Grant No. 451-03-68/2020-14 /200162).

References

Ferreira, N. P., Human, H. G. C. and Butler, L. R. P. : 1980, *Spectrochim. Acta Part B*, **35**, 287.

Ivanović, N. V., Šišović, N. M., Spasojević, Dj. and Konjević, N. : 2017, *J. Phys. D: Appl. Phys.*, **50**, 125201.

Ivanović, N.V. : 2019, *Atoms*, **7**, 9.

Jäger, H. and Windholz, L. : 1984, *Phys. Scr.*, **29**, 344.

Jäger, H., Windholz, L. and Ziegelbecker, R. Ch. : 1989, *Phys. Scr.*, **40**, 740.

Kuraica, M., Konjević, N., Platiša, M. and Pantelić, D. : 1992, *Spectrochim. Acta Part B* **47**, 1173.

Majstorović, G. Lj., Ivanović, N. V., Šišović, N. M., Djurović, S. and Konjević, N. : 2013, *Plasma Sources Sci. Technol.*, **22**, 045015.

Ryde, N. : 1976, *Atoms and Molecules in Electric Fields*, Almqvist & Wiksell, Stockholm.

Šišović, N. M., Ivanović, N. V., Majstorović, G. Lj. and Konjević, N. : 2014, *J. Anal. At. Spectrom.*, **29**, 2058.

Windholz, L. : 1980, *Phys. Scr.,* **21**, 67.

Windholz, L. and Neureiter, C. : 1988, *Phys Rev.* A, **37**, 1978.

Ziegelbecker, R. Ch. and Schnizer, B. : 1987, *Z. Phys. D,* **6**, 327.