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ON THE USE OF RELATIVE LINE INTENSITIES OF FORBIDDEN AND ALLOWED COMPONENTS OF THE He I 447.1 nm LINE FOR ELECTRIC FIELD MEASUREMENTS

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1. INTRODUCTION

Recently we have reported measurements of electric field strength in the cathode fall region of an analytical glow discharge, determined from Stark splitting and shifting of three visible He I lines and their forbidden components (Kuraica *et al.*, 1997). In this paper, we present the results of an attempt to use relative line intensities of the He I 447.1 nm allowed line (2p $^3P^0$ - 4d $^3D^0$) and its forbidden component (2p $^3P^0$ – 4f $^3F^0$) for the measurement of electric field strength in the cathode fall region of the same analytical glow discharge (GD) in helium-hydrogen mixture. For determination of electric field strengths we calculated the He I relative line intensities following classical Foster's paper (Foster, 1927). An experimental testing of electric field measurements in helium-hydrogen mixture is performed using Stark spectroscopy of the hydrogen Balmer H_β line (Videnović *et al.*, 1996).

2. EXPERIMENT

The experimental setup is presented schematically in Fig.1. Our discharge source, a modified Grimm GD is laboratory made and described in detail elsewhere (Kuraica *et al.*, 1992, 1997). Here, for completeness, minimum details will be given. The hollow anode 30 mm long with inner and outer diameters 8.00 mm and 13 mm, has a longitudinal slot (15 mm long and 1 mm wide) for side-on observations along the discharge axis. The water cooled cathode holder has an exchangeable iron electrode, 18 mm long and 7.60 mm in diameter, which screws tightly into its holder to ensure good cooling. A gas flow of about 300 cm^3/min of helium-hydrogen mixture (95% He : 5% H_2) is sustained at a pressure of 200 Pa by means of needle valve and a two-stage mechanical vacuum pump. To run the discharge a 0-2 kV, 0-100 mA current stabilized power suply is used. A ballast resistor of 10 kΩ is placed in series with the discharge and the power supply.

After polarization with a Glan-Thomson prism or a plastic polarizer, the radiation from the discharge source is focused with unity magnification (8 cm focal length achromat lens) onto the entrance slit of the scanning monochromator-photomuliplier system, see Fig.1. For electric field intensity axial distribution measurements, the discharge tube is translated in ≈0.1 mm steps by a stepping motor, so that the discharge image obtained through the observation slot is translated in the plane of the entrance slit (30 μm) of the monochromator. For the spectral recordings, 4 m Hilger and Watts Ebert type spectrometer with inverse dispersion of 0.242 nm/mm is used. All spectra are recorded with 30 μm entrance and exit slits, giving a Gaussian instrumental profile with 0.022 nm half-width. The monochromator is equipped with a stepping motor which enables minimum wavelength change in steps of 0.0028 nm. For radiation detection, a photomultiplier with Peltier cooling is used. A lock-in signal amplification technique is employed. The entire experiment is controlled by a PC. The same computer is used for data acquisition and analysis.

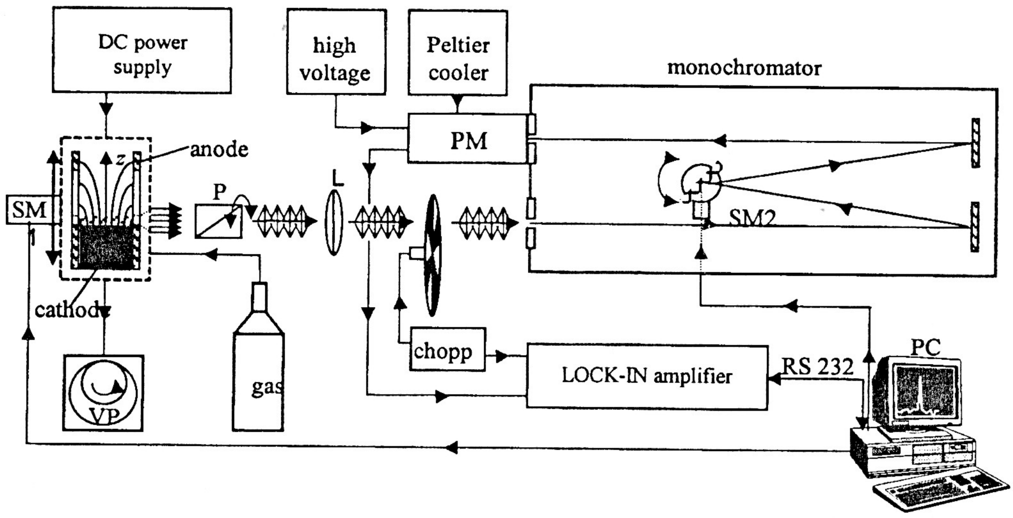

Fig. 1. Schematic diagram of the central part of Grimm GDS and experimental setup for side-on observations. Symbols: VP - vacuum pump, SM 1 and SM 2 - stepping motors; P - polarizer; L - lens; PM - photomultiplier.

3. RESULTS AND DISCUSSION

As an illustration of the influence of electric field strength on the He I 447.1 nm allowed line and its forbidden component intensities, typical π-polarized spectra recorded in the cathode fall region of our GD, at electric field strength 12.1 kV/cm, is given in Fig.2. Both, allowed and forbidden lines marked in this figure contain two π-components which cannot be resolved in our experimental conditions, see Fig.2. The third feature, marked with *ff* in Fig.2, originates from the discharge protruding through the longitudinal observation slot into the field free space (Kuraica *et al.*, 1997). Therefore, in order to estimate the total intensity of unresolved two π-components of allowed line, it is necessary to subtract the radiation intensity of the *ff* feature from the overall profile. This is done by fitting the experimental data with two independent Gaussian profiles. Than, from the whole fit, the area of the *ff* profile is subtracted. The results of forbidden-to-allowed He I π-profile intensity ratios, measured along the cathode fall region of our GD (at various electric field strengths, determined from H_β line shapes at same positions, see Kuraica *et al.*, 1997), are given in Fig.3. The solid line in Fig.3. represents our calculation of theoretical intensity ratios for this line following Foster (1927).

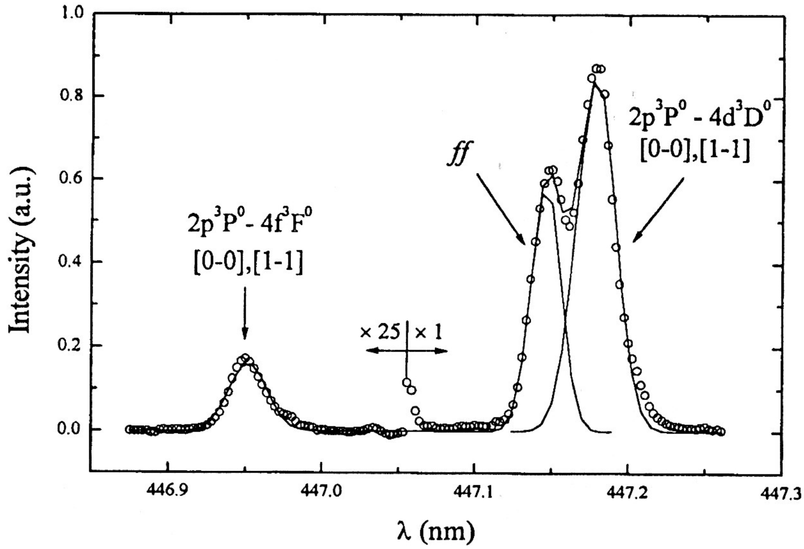

Fig.2. Typical π-polarized spectra recording of the He I 447.1 nm allowed line and its forbidden component at electric field strength of 12.1 kV/cm in the cathode fall region.

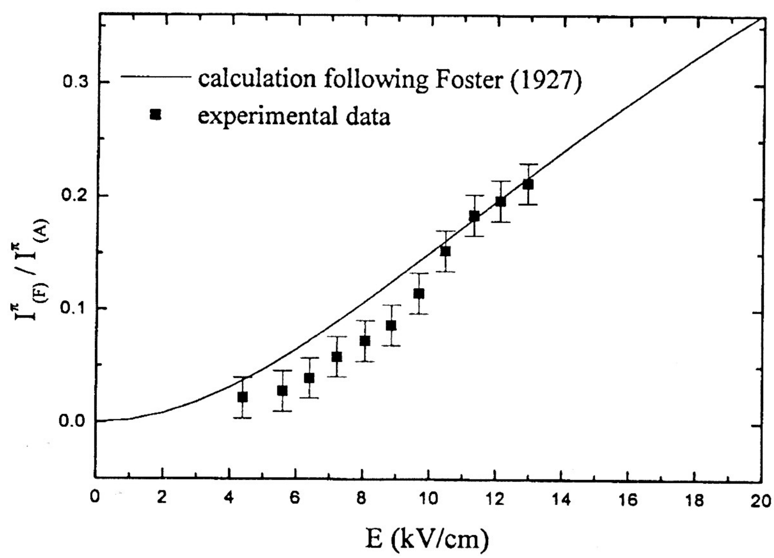

Fig.3. Comparison of experimental and theoretical intensity ratios of π-components of the He I 447.1 nm allowed and its forbidden line.

Electric field strength is determined from the H_β line shapes at same positions (Videnović *et al.*, 1996). From the comparison of our experimental and theoretical data in Fig.3, one may conclude that, in spite of some difficulties like e.g. deviation from theoretical predictions at low electric field strengths, intensity ratios of the π-components of forbidden and allowed He I 447.1 nm line may be used for electric field measurements. At low electric fields, the partial overlapping of the the *ff* feature with allowed line makes the substraction of the *ff* line impossible, which results in increasing the allowed line total intensity. Consequently, the intensity ratio shows systematical decrease at low electric fields.

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